Guest Editors:

Lorenzo Desideri, Luc de Witte, Rabih Chattat and Evert-Jan Hoogerwerf

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ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA

TECHNOLOGY AND DISABILITY
Volume 31, Supplement 1, 2019

Special Issue: AAATE 2019 Conference – Global Challenges in Assistive Technology: Research, Policy & Practice, 27–30 August 2019, Bologna, Italy
Guest Editors: Lorenzo Desideri, Luc de Witte, Rabih Chattat and Evert-Jan Hoogerwerf

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Technology and Disability 31 (2019) S1
DOI 10.3233/TAD-190001
IOS Press

Foreword by AAATE President

The field of Assistive Technology (AT) is getting more and more attention, on global as well as local/national levels. After a period in which AT in many European countries almost disappeared from the political and policy radars, we are now seeing an increased awareness of its relevance again. The GATE initiative of the WHO that has led to the adoption of an important resolution on improving access to AT plays an important role in that, and also the UN Convention on the Rights of Persons with Disabilities (CRPD) is an important driver. More 'down to earth' countries start to realise that AT can play a role in tackling the enormous challenge to maintain high quality affordable health and social care systems.

This growing attention for AT is a good thing. Technology can be a powerful tool to enable people with disabilities to live the life they want to live and make them as independent of care and support as possible. And technology can indeed reduce the burden on our healthcare systems. But that does not happen as a matter of course, because the same technology can also be a barrier to full inclusion of people with disabilities in society, and an extra complicating and costly addition to an already complex healthcare system if not properly used and implemented. Here lies a fantastic challenge for the international professional and research and development communities: how to make sure that AT is developed, used and implemented in the best possible way, so that its potential is harnessed and contributes to full inclusion of people with disabilities. That is a global challenge; we know that in many countries people with disabilities have very limited or no access to AT and that in many other countries the match between needs and technologies is far from optimal. So, there is work to be done!

The above explains why the motto of the AAATE conference in 2019 is "Global Challenges in Assistive Technology". For the AAATE this conference is a key element in its activities. The aim is to bring experts in the field of AT – professionals, researchers, developers, teachers, policy-makers and users – together to exchange knowledge, discuss progress, develop ideas and challenge each other to deliver the best possible contribution to this important field.

The more than 200 contributions to this conference clearly show the breadth of the field, the many challenges, the great opportunities, interesting research questions, possible future directions, global collaboration and many more topics. The AAATE conference is unique in its attempts to give a comprehensive overview of the 'AT world' crossing the boundaries of technology specialisations, user groups and stakeholder categories. The abstracts presented in these proceedings together give a good overview of what is going on and what will be future trends. This will help to define research and policy agendas and stimulate new collaborations and links.

Luc de Witte
President of AAATE

ISSN 1055-4181/19/$35.00

Technology and Disability 31 (2019) S3
DOI 10.3233/TAD-190002
IOS Press

Foreword by the Conference Chairs

Dear colleagues,

It is a great pleasure to present the proceedings of the 15th International Conference of the Association for the Advancement of Assistive Technology in Europe for your appreciation. The conference, taking place in Bologna (Italy) at the end of August 2019, covers as usual a wide variety of themes having to do with the relation between Technology and Disability. Beside the more traditional areas of Assistive Technology this includes Accessibility, Universal Design, Ambient Assisted Living, Smart environments and Internet of Things, Robotics, Technologies for independent living and self-management, Rehabilitation technology, Technology for Ageing, Augmentative and Alternative Communication, etc. It is a precise choice of the conference organisers, fully in line with the mission and positioning of AAATE as a European AT association of reference, not to specialise in any of those fields, but to keep this broad perspective, adopting the standpoint of those searching for effective assistive technology based solutions for their empowerment and for whom all solutions are open, as long as they work well. This approach makes the AAATE conference probably the most all-round AT conference in Europe and a biannual "must" for professionals supporting persons with disabilities and older adults. As a matter of fact, reading through the selected abstracts brought together in these Proceedings, the reader get a good picture of the broadness of the field and the wealth of competence represented by the authors.

We would like to thank the Programme Committee, in particular Lorenzo Desideri of AIAS Bologna, and the Scientific Committee Members for the work done in collecting, reviewing and selecting the abstracts here presented. They form the main scientific heritage of this conference, together with other reports that will be made from the educational sessions, the policy sessions and the product and prototype presentations. For organisational reasons it was not possible to include all that material in these proceedings.

Finally we would like to thank the authors that have chosen the AAATE conference to present their work. We have appreciated your effort and congratulate you with the high level of the work presented.

The Conference Chairs
Evert-Jan Hoogerwerf (AIAS Bologna onlus)
Rabih Chattat (Alma Mater Studiorum University of Bologna)
Luc de Witte (AAATE)

ISSN 1055-4181/19/$35.00

Technology and Disability 31 (2019) S5–S6
DOI 10.3233/TAD-190003
IOS Press

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ISSN 1055-4181/19/$35.00

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Technology and Disability 31 (2019) S7–S107
DOI 10.3233/TAD-190004
IOS Press

Part 1: Special Thematic Sessions

Special Thematic Session 1
Cognitive Accessibility of Digital Resources

The cognitive accessibility of digital resources is still a major research topic and is insufficiently covered by existing solutions and current accessibility guidelines. People with cognitive limitations can only use digital resources to a limited extent or not at all because they do not understand the available information or cannot orient themselves sufficiently on complex websites. The project Easy Reading tries to solve these problems by creating an environment that allows to adapt the accessibility of websites to the individual support needs of the users. The software framework developed within the scope of the project provides tools for adapting the layout and structure of web pages, for enriching the content of web pages with symbols, images and videos, or for translating web content into a different language level (e.g. plain language or simplified language). In this way, users with cognitive limitations as well as users who have difficulties understanding the original content due to their age, technical experience or migration background can work with the original sources and access all information and services resources. The Easy Reading framework is planned as a cloud based, open source and freely available support infrastructure. In this way, the framework supports the integration and use of state-of-the-art and future research and development. It combines tools for individual user-centric annotation, customization, translation and personalization. In this Special Topic Session the motivation, the project objectives and the current project results will be presented and discussed. Further contributions from similar research projects are also welcome.
Chairs: *Christian Bühler*, *Ingo Bosse*, *Susanne Dirks*

GAP REDUCE. A Research & Development Project Aiming at Developing a Tool for Promoting Quality of Urban Life of People with Autism Spectrum Disorder

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Background: The paper reports the first results of a two years ongoing research and development project called "GAP REDUCE" aimed at promoting the possibility of people with Autism Spectrum Disorder (primarily adult and high-functioning) of walking autonomously and safely across the city. The purpose is the design and development of a Web App able to support ASD people to plan, easily and in advance, an urban itinerary towards possible daily destinations. The project is part of a wider research that investigates the specific topic of the relationship between people with autism and the city with the aim of designing an integrated system of urban mobility policies, projects and tools for supporting the real opportunity for them to "use" the city every day. Some considerations motivated the research: the growing incidence of ASD, the almost exclusive focus of existing studies and applications concerning people with autism (mainly children) and space on the design of dedicated, separated, closed and private spaces, and the need of guarantee even during adulthood the actual opportunity to exercise the level of autonomy achieved during educational and therapeutic paths.
Method: The first part of the research dealt primarily on two distinct aspects: one regarding a cognitive framework of autism directed to identify the urban spatial elements that can facilitate or hinder the possibility of ASD people of walking together with the communicative and educational tools to deal with problematic behaviors; the second concerns the design and development of a digital tool, i.e. a Web App, that implements the requirements, assumptions and outputs achieved in the first phase. The App automatically generates routes using spatial elements as waypoints and evaluates these routes suggesting the most suitable path for ASD users. The App is also equipped with a graphic

ISSN 1055-4181/19/$35.00

user interface which permits to show visual instructions on how to overcome situations considered critical (e.g. encountering crowded places, crossing high volume traffic intersections).
A neighborhood in the city of Sassari (Italy) was selected as pilot study area.
Key results: According to the methodological assumptions, during the phases of data collection and first calibration of the algorithm two needs became apparent and influenced the following steps: the necessity to classify the urban spatial elements into two categories: positive and negative Points Of Interest acting as spatial facilitators or obstacles respectively and the need to characterise each POI through a set of attributes to be considered in the evaluation of the most suitable path. Thus three different types of elements have been identified:

a) *POIs* are the spatial features collected and mapped with GIS;
b) *waypoints* corresponding to the positive POIs that are part of the calculated route;
c) *critical points* corresponding to the negative POIs along the route.

The preferable route will be identified initially on the basis of waypoints number and path length, then an evaluation procedure will consider the quality of POIs along the route.
By mean of marker functionality the app will provide a graphical representation of the POIs through texts and images that support the user especially in critical circumstances.
Conclusion: Starting from these first results, a mapping phase will be carried out in the pilot study area with the aim of identifying the spatial elements corresponding to the waypoints and critical points and, in a more advanced stage of the project, a test phase will be carried out with a group of users with high functioning autism.
The functional structure of GAP REDUCE makes it a flexible tool with possible further developments also with respect to the spatial needs of other groups of inhabitants (elderly, people with dementia, people with other sensory disabilities). Beside promoting the autonomy of movement in the city it can also support urban planning processes towards the development of more inclusive and accessible environments for everyone.
Keywords: City and People with Autism, Quality of Urban Life, Urban Capabilities, Web App.
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Cognitive and Learning Disabilities work at W3C and for the Easy Reading Project
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Background: People with cognitive and learning disabilities face a broad range of accessibility barriers in websites and applications. While the W3C Web Content Accessibility Guidelines (WCAG) standard includes requirements ("Success Criteria") that facilitate accessibility for people with cognitive and learning disabilities, the issues and their resolution are often less well understood by designers and developers. Further, many cognitive accessibility techniques require adaptation or personalization by an Assistive Technology (AT), which are not yet well documented. Thus, there is a growing need for a larger corpus of explanatory material and implementable techniques from the W3C Web Accessibility Initiative (WAI), to help minimize these cognitive accessibility barriers.
Method: The W3C Cognitive and Learning Disabilities Accessibility Task Force is developing resources that provide background, requirements, gap analysis, and guidance on designing user interfaces (UI) and content for cognitive accessibility. These supplement the techniques detailed in WCAG. The W3C Personalization Task Force is developing resources for personalized adaptation of content and user interfaces. This allows content marked up with alternative formats to be selected according to user preferences. The EU Horizon 2020 project, Easy Reading, is developing a new Assistive Technology (AT) Framework to provide personalized adaptation for cognitive accessibility. This is will adapt to user preferences with real-time adjustments by monitoring user interactions. As a project consortium partner, the W3C are ensuring harmonization between the project Framework and W3C resources. Any new requirements or techniques uncovered during the project will be included in W3C's resources to maximize impact. In addition, engagement during the project's technical development allows the project's deliverables to benefit from the knowledge already encapsulated in W3C resources.
Key results: The project's Inclusive Participatory Action Research technique and Framework implementation helped improve the W3C cognitive accessibility and personalization resources. This enhanced knowledge may also lead to additional WCAG Success Criteria. The W3C's corpus of cognitive accessibility and personalization knowledge supports sustainability of the project outputs and ensures further dissemination

through integration into existing international standards and supporting guidance.
The Easy Reading Framework is providing a required implementation to validate the W3C techniques in a real world solution. Thus, the W3C guidelines are both distilling new project learnings and also informing the work.
Conclusion: There is a growing awareness of cognitive accessibility user requirements and barriers along with the importance of addressing them at source. Thus, it's an opportune time to be part of the Easy Reading project and to enhance the W3C standards and resources. The Easy Reading project's personalized adaptation framework provides new understanding of user requirements and practical solutions, as well as being as useful Assistive Technology in its own right.
There is now a useful introduction to requirements, enhanced standards, guidelines and techniques that commissioners, designers and developers can use to improve the experience of many.
As a result, the experiences of people with cognitive and learning disabilities can be improved by application of these internationally recognized resources. The W3C operates an open consensus process so others are encouraged to collaborate to further improve cognitive accessibility.
Keywords: Cognitive, personalization, adaptation.
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Inclusive Participatory Evaluation and Analysis with Peer-Researchers with Cognitive Disabilites – an Innovative Approach

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Background: The Project Easy Reading focuses on the individual support needs of the users with cognitive disability while going online. One of the main starting points is the fact that every person is different and therefore needs different support browsing the internet. We believe that a person knows her or his own needs the best and therefore consider people with cognitive disability as experts for themselves They know the barriers they face, so they should be included in research regarding software that is aimed to help people with cognitive disability.
Method: The whole Project is based on a User-Centred-Design (UCD) Approach and includes the Inclusive Participatory Action Research (IPAR). One of the main goals of the project is the combination of these two approaches into one approach: the IPAR-UCD concept. IPAR-UCD describes that the users who will in the end use the software are part of the development of the software.
In the Project 16 Peer-Researchers with different levels of understanding, different level of writing and reading and different level of attention and memory are working in three different organisations taking part in the research process. All three organisations such as Proqualis, DART and PIKSL are participating as partners in the Easy Reading Project. The Peer-Researchers with a cognitive disability are integrated in the whole process of the project.
Key results: After giving a short introduction on the methods used in the project, we will concentrate on some examples of the practical work with the Peer-Researchers: One big part of the project is the User Testing of the Easy Reading Browser Plug-in. The Peer-Researchers are the ones who will carry out the User Testing. For valid and reliable testing, we are working with Test Cases. That means during the project we have to find ways that people with cognitive disability who also cannot read or write are able to work with the Test Cases. We will show the different states of the Test Cases and reflect on the how they were developed in an inclusive team of researchers and peer-researchers. We will outline the iterative way of working in detail and show how it is possible to work in an inclusive team.
Conclusion: Working in an inclusive Team of Researchers and Peer-Researchers based on the IPAR-UCD approach is an innovative way of working in Software Development Projects. Including experts with an own cognitive disability during the development process rises the chances of the acceptance in the End User Group.
Keywords: Inclusion, Participatory Research, Accessibility, Usability.
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Automated Adaptation of Content and Structure of Original Web pages

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Introduction: Creating a good user experience (UX) is key to obtaining and retaining visitors on the web. Countless studies show that for each second your page is in an unusable, unreadable or unresponsive state the drop off rate rises rapidly. Allot of time, effort and money goes into making sure that the UX of a modern website is good, so why doesn't this also always apply to accessibility? One of the main issues with accessibility on the web is the lack of enforcement for accessibility standards within websites. There are guidelines set out by the W3C, such as the Web Content Accessibility Guidelines (WCAG). The 3 levels of these guidelines have only been made a lawful requirement for the public, private or government sector in varying laws within each country, if at all. Even then, if these laws were to apply to all sites it would be an enormous task to enforce it. There are various tools available to check the accessibility of your website however it requires you to use them and then implement solutions to address them.
Methods: With this in mind, how can an accessibility tool be created using a one size fits all solution? It can't. Instead of fully relying on web standards to have been followed we can create engines and algorithms to read the underlying code and structure of a webpage and break this down into various sections. For example, take a typical news article website, we can assume that this will be made up of 3 main sections – the navigation, the content and everything else (comments, adverts, etc.). The user would most likely be interested in the content and navigation so we can use these scripts to adapt this content more suitably for the user. The EasyReading project incorporates peer researchers into a somewhat iterative development process. This allows us to see what areas the end users are having major issues in and adapt or improve the engines accordingly.
Conclusion: Recent advances in technology may be able to help create a state of the art solution. Whilst the development of the EasyReading framework and its engines is still underway, we are looking at how different technologies can be used to automatically adapt and read the content and structure of web pages using Document Object Model (DOM) manipulation, scripting and machine learning. Then look into how to make this content accessible through translation, annotation, and adaption. These engines can then be used within the EasyReading framework to customize a user's experience to their accessibility needs.
Keywords: Accessibility, web, EasyReading, Java Script, Machine Learning.
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Adaptive User Interface Concepts Supporting People with Cognitive Disabilities

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Background: The concept of user interfaces supporting means for automatic adaptation to the requirements, skills or environment of the individual users shows great potential towards enhanced usability and accessibility. Systems that support different user interface concepts and different HCI paradigms enable users with cognitive disabilities to operate them in a familiar manner. This abstract describes how such adaptive user interfaces and interface concepts are developed and evaluated within EasyReading, a framework that allows users to get personalized support for web content in real-time. Framework interfaces and the produced adapted content are directly injected into the web-page, enabling the user to work directly with the original digital content of the page. The resulting architecture adapts to the users' needs in the following ways:

- Presentation of the user interface
- HCI paradigms used to trigger framework functions
- Functions for converting content into an alternative, easier to understand, format
- Presentation of the framework results to the end user

As the architecture is component based, new user interfaces, HCI paradigms and functions can be added and adjusted for the individual user. This abstract should give an overview on the benefits of such an adaptive system as well as its evaluation.
Method: Development within the project is driven by the principle "Nothing about us without us". Therefore, the project cooperates closely with three end user groups from Austria, Germany and Sweden that work as co-researchers in the project in an inclusive ap-

proach. Framework components such as user interfaces and widgets supporting different HCI paradigms are developed together with a single user-group and then tested by the remaining user groups. Based on the outcomes of the testing, the components are refined and further developed until they are approved. Newly developed components are then classified, so that they can be later on matched with a user profile to create solutions for the individual user.

Key results: The first set of components was developed using the aforementioned inclusive approach and the first user tests are ongoing. First results of the ongoing user tests show that there is a strong need for adaptability by the target group. As the abilities and preferences of the user group are divergent, a one-size-fits all approach does not suit. For example, users required different HCI paradigms to be supported when paragraphs present on Web pages had to be adapted for their easier understanding. For some users it felt natural to select the kind of help they would need and then just click on the paragraph, while others preferred to select the text by marking it with the mouse and then clicking a button that would enable the helping functionality.

Conclusion: Adaptable user interface can greatly increase accessibility of systems as they are able to support the different needs of the individual user.

Keywords: accessibility, adaptive user interfaces, people with cognitive disabilities.

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Safety, Privacy and Ethical Considerations when Researching With People with Cognitive Disabilities

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Background: For many people with cognitive disabilities, it's difficult to access the web on equal terms with others. The needs of those who has difficulties navigating and understanding web content are often dependent on context, which makes it difficult to standardize solutions. In the project Easy Reading, peer researchers with own experiences of cognitive disability work together with developers to design a solution to personalize the experience on the web. The question of ethics is essential and concerns both the research process with users and the privacy and security of the technology. The aim has been to produce guidelines on ethical considerations to support the work during the project and to perform a risk analysis to identify and assess ethical risks.

Method: The framework of ethics within the project concerns issues like informed consent, design principles, the role of an ombudsman and personal data. Existing regulations and guidelines and previous research results on this were studied, and best practices on how to research and develop together with the target group were put together. To assess the risks, an ICT risk matrix from Queensland Government was used. It measures how likely the risk is and how serious its impact is and results in a combined risk score, labeled in five steps. All documents will be used as a basis as the project carries on.

Key results: To make sure participants with cognitive disabilities understand the meaning of participating, accessible information sheets and consent forms are important. Such forms were created written in simple language with pictures to support the text.

Basic principles for developing interfaces suitable for users with cognitive disabilities were identified. Systems should be easy to use and allow mistakes and they should be responsive and reliable. Users must be in control of their privacy and systems must comply with data regulations. The role of ombudsman is important to safeguard the safety of participants. It's important that the ombudsman fulfils requirements such as being located in the same area, being familiar with the target group and have legal knowledge. The target group is vulnerable when it comes to understanding and consenting to data collection and their data might be sensitive. Therefore, it's important to only collect the data needed, only keep the data for as long as necessary and only give access to those who need it. The risk assessment includes risks related to the technology and to the research carried out with peer researchers and testers.Checklists focused on the above areas were provided to facilitate practical work.

Conclusion: The question of ethics has to be present where users are involved in the process, and particularly where technology can capture so much information. Data collection must consider the privacy and security aspects. Results from the work done in this project's ethics work package, including practical guidelines and checklists as well as insights into common risks, will be valuable for coming projects, application development processes and user testing within the field of assistive technology.

Keywords: Ethics, Privacy, Inclusive design, Peer researchers.
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New Approaches to Web User Tracking

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Background: User tracking in the Easy Reading context differs from the usual understanding of the term as in website visitor tracking (with main focus on marketing purposes). In Easy Reading the focus is on tracking of a user's cognitive load while actually viewing a webpage. Ideally a user needs to make sense of the page on his or her first visit or it might be the last visit. So, in addition to page navigation data through mouse movements and clicks, it will be necessary to introduce additional sensors which can expose certain data on a user's cognitive state.
Method: To solve the problem stated above, first the state of the art in user tracking was analysed. Then current approaches towards the detection of cognitive load were investigated. With certain user-related requirements in mind, like unobtrusiveness, affordability, ease of use and reliability, certain interesting parameters for user tracking in the Easy Reading context were defined.
Key results: The sensors that have been considered most important for future work are eye trackers, fitness trackers and webcams. While the main purpose of eye tracking is to show the user's present point of focus, also additional information can be derived from it. Fixations (200–300 ms or longer) can give an indication of cognitive load when they are long, but come at a low rate. The same applies for Micro-Saccades (fast movements of 30–80 ms in two directions) that come with high velocity and length. A further useful parameter would be pupil dilation, which has long been known to raise on cognitive load. Sadly this can only be measured with professional eye trackers that come at a high price, therefore being in conflict with the requirement of affordability. The purpose of the fitness tracker is to deliver heart rate data. This can be used in two ways: number one the pulse rate itself can help to detect stress (does the pulse raise without the user getting up?) and number two, the Heart Rate Variability (HRV) can be used to measure activity of the autonomic nervous system. HRV is known to respond quickly to changes in a person's cognitive state. Finally, the webcam can be used to detect the user's blink rate, giving an additional indication of the user's state. Specifically when eye blinks come at a low rate and with high latency, it can be an indication of high cognitive load.
Conclusion: All data mentioned above can only be seen as parts of a puzzle. While any isolated parameter will produce many false positives, it is assumed that considered together they will give a more or less clear picture of the user's current cognitive state. This will help to present information in a more adequate way for the individual user and therefore significantly push information accessibility for people with cognitive disabilities, as well as people with other kinds of comprehension problems, like people with a low level of education or people facing a language barrier.
Keywords: User tracking, cognitive load, eye tracking, HRV.
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Special Thematic Session 2
User Participation in Software Development

User participation in the development of products and services is generally regarded as one of the key factors for sustainable development. In recent decades, user participation in software development has improved significantly. During software development, users are typically involved in the early stages of development, in requirements analysis and evaluation. Despite this improvement, however, there are still many development phases in which users are not involved due to cost and time constraints, which in many cases leads to limited usability and acceptance of the developed products. Since it is often already difficult to include users without impairments in all phases of the software development cycle, the question arises how user participation is realized in projects in which software products are developed for people with impairments. In the workshop described here, approaches and procedures for user participation of people with different impairments from various research projects, currently funded by the EU, will be presented and discussed.
Chairs: *Christian Bühler*, *Ingo Bosse*, *Susanne Dirks*

Participation of Users with Disabilities in Software Development Projects

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Background: Without any doubt, every project manager in software development will confirm that highly usable products can only be developed through active user participation in the development process. User participation is one of the most important factors for project success. In projects where the potential users are involved in the product development, better software is developed and the satisfaction of developers and users with the work processes and the product development is higher. So much for theory – in real life, user participation in software development is somewhat different, especially if the potential user group consists of people with disabilities or other particularly vulnerable people. In addition to insufficient organizational and financial resources, software projects often lack suitable methods and trained developers and interface designers to successfully integrate users with impairments into the development process. In the scope of the presented work, opportunities and challenges of participative software development with people with disabilities were analyzed and discussed and solutions to the most occurring challenges were developed.
Method: In addition to the results of an extensive literature analysis, experiences from various software development projects of the authors were gathered and analyzed, e.g. from the H2020-funded project 'Easy Reading'. Special problems of the different user groups using standard software products, different methodological approaches to user participation and processes of participatory software development projects were analyzed. The systematized challenges and opportunities in participative development projects were then categorized, prioritized and related to different methodological approaches. Based on this, solutions for the most common problems in participative software development with people with different disabilities were developed.
Key results: Most of the common problems in participative software development projects could also be found for the user groups with impairments. However, a number of other problems arose due to the particular characteristics of the respective user groups. For people with motor and sensory impairments, the main problems were the configuration and accessibility of working environments and materials. For people with cognitive impairments, the identified problems were primarily related to the communication within the project, the design of the working materials and the interaction between the project participants. Although agile software development contradicts user-centered development in some aspects, the agile approach with some adaptations proved to be well suited for participatory software development with people with disabilities.
Conclusion: For more effective involvement of users with impairments in software development projects, suitable methods are lacking. The presented work has shown that agile approaches form a good basis for participative software development if they are extended by methods that address the particular requirements of users with impairments.
Keywords: user participation, software engineering, accessibility, agile approaches.

Assistive Technology for People with Profound Intellectual and Multiple Disabilities

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Background: People with profound intellectual and multiple disabilities (PIMD) often communicate on a pre-symbolic level and use unconventional behaviour signals (e.g. specific body movements or vocalizations) to express their needs. The number of those interaction partners who are capable of accurately perceiving and interpreting these specific and highly individual behaviour signals is very limited in most cases. This significantly restricts the participation of this group in all areas of life. INSENSION is an European project focusing on better understanding of the behaviour signals by using the advances of unobtrusive technological recognition tools. Facilitating the communication of and towards people with PIMD could contribute to improve their participation and quality of life. This will be realized by creating a technologically supported responsive environment, which automatically analyses and interprets various behaviour signals against the background of the particular context.
Method: The study has been started with assessing the behaviour signals of six test persons by different methodical approaches:

– based on renowned assessment tools, a comprehensive assessment (questionnaire for their close rela-

tives as well as for direct support professionals) collects information on communication and inner states
– recordings of the test persons using state of the art technology combined with monitoring of physiological parameters by means of the Empatica E4 wristband to analyse facial expressions, gestures, vocalizations and physiological signals
– focus group workshops with close relatives, direct support professionals and IT specialists

Key results: In our presentation, we focus on preliminary findings of the focus group workshops which took place in Poland and Germany moderated according to the Walt-Disney-Method by Dilts (1991) and the additional use of particular methods of the Design Thinking approach like the creation of personas to exemplify the target group. Within the scope of three workshops, the participants defined those situations within the life of people with PIMD, which are most challenging for the target group itself as well as for their direct support persons. Based on the findings of the focus group workshops and based on the collected data of the recordings and the assessment, three applications have been determined to provide technological support. The applications focus on communication, the use of multimedia player and robotic assistance devices. Each application aims to provide remedy in challenging scenarios in order to increase the self-determination of people with PIMD and to improve the quality of their lives.

Conclusion: After the implementation of the main INSENSION system in a specific environment, the design process of the determined application is envisaged. Therefore, the inclusion of later users represented by their direct support persons plays an important role in terms of usability since their participation enables an orientation towards the users particular needs and wishes.

Keywords: People with profound intellectual and multiple disabilities, assessment of communication, focus group workshops, information and communications technology.

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Usability Evaluation of Mobile Application for Persons with Disabilities: A Review of Available Tools

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Background: The use of mobile applications is increasing among persons with disabilities (PwD) (Csapó et al., 2015). Apps and mobile devices can represent an affordable assistive alternative to traditional expensive technologies in facing daily challenges (Brady et al., 2013). Therefore, the choice of accessible and usable applications becomes fundamental and must take into consideration the users' specific needs. However, the selection of suitable apps can be difficult, due to their large number rapid growth and development, and because most of them "are untested and unregulated" (Moran, 2018: 10). This requires the identification of specific evaluation tools enabling PwD "to navigate in this evolving app space" (Kim et al., 2018:1). Research in the field has already brought to evidence some of these tools, which investigate the usability of mobile application for PwD (Harrison at al., 2013). Usability, in fact, is based on the user experience design and represents "the extent to which a product can be used by specific users to achieve specific goals with effectiveness, efficiency and satisfaction" (ISO, 1998). The several components of usability can be used to make decisions about the choice of a software (Goel et al., 2018). This study aims at reviewing existing research on tools used for evaluating usability of applications designed for PwD. This will enable the identification of the different components of usability, in order to introduce new tools or guidelines for helping PwD in making self-determined choices.

Method: On 01-22-2019, a literature review was conducted on Science Direct, IEEExplore, ACM Digital Library and Google Scholar to identify primary studies, published from 1998 to 2019. The keywords were "usability evaluation" AND "mobile application" AND "persons with disabilities".

Key results: Thirty prominent studies were found, from which five tools were identified, namely *PACMAD usability model* (Harrison et al., 2013), *Quality criteria assessment scale* (Reynoldson et al., 2014), *Mobile device app evaluation rubric* (Ok et al., 2016), *Subjective Usability Scale* (Reeder et al., 2016), *Health-ITUEM* (Brown III et al., 2018). Each tool is composed of items, grouped in categories, corresponding to usability dimensions defined by the authors. They were applied to evaluate the usability of a certain group of apps (e.g. m-health) and addressed to a specific disability. They are based on different methodologies (yes/no scale, Likert scale, open-end answers) and the assessment was performed predominantly by caregivers, therefore the tools did not directly record the user experience.

Conclusion: This study identified different tools, related to the diverse usability constructs adopted. It emerged their low generalizability and a low involvement of PwD in their evaluation process. Instead, a usability tool that involves direct cooperation with PwD would provide a more insightful assessment. This study highlighted the need of a more thorough evaluation of the importance of the relationship between accessibility and usability in establishing the quality of PwD assistive software. The work also elucidated the necessity to establish regulatory standards, in order to achieve higher quality applications and to promote a universal attitude towards accessibility and inclusion pertaining to PwD.

Keywords: mobile application, usability evaluation, self-determination.

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Inclusive Collaboration in R&D for Improved Cognitive Accessiblity

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Background: e-inclusion entails empowering people to participate independently in digital society including people with disabilities. Usability and User-Experience Design describe user-oriented or user-centered design processes (UCD). The knowledge of UCD is scientifically established and proven for the implementation of assistive technology and e-Accessibility for people with disabilities except for those with cognitive disabilities. So far, there is no full participation of the target group as researchers or experts. Furthermore, there is a lack of methods and tools to support communication and interaction in research and development (R&D). Although there are inclusive research approaches in social sciences, there is still none in the field of software-engineering. In the ongoing Easy Reading Project with the IPAR-UCD concept (a combination of Inclusive Participatory Action Research and User-Centred Design), we demonstrate that adequate attention and the creativity of researchers and developers, as well as the adaptation and (further) development of usability methods and tools, can lead to the inclusion of potential users as peer researchers in user-centered R&D processes.

Method: Development and advancement of the inclusive IPAR-UCD concept are based on the "Design-Based Research" approach. This approach is an independent type of qualitative research methodology. IPAR-UCD was examined and further developed with peer-researchers in the EU-funded Easy Reading project. These "interventions" allow for evaluation of how well IPAR-UCD solutions work. The data analysis uses the iterative comparison cycles. These could be adapted and re-tested. During the project, academic researchers initially collaborate with the peer researchers as target group for a requirement analysis. The IPAR-UCD concept addresses peer researchers' need for support by helping software designers and developers to better understand and meet the requirements of users with cognitive disabilities through the inclusive user-centered design process. Later, peer-researchers alone or as group communicate their thoughts and experiences with the prototype. As input for a new software system, the feedback from users identifies useful features and problems. In this way, the developers receive feedback directly from the future user. Ideas and developments fit together or have to be further adapted thus ensuring accuracy in the development process. As focus-groups the research teams use methods such as brainstorming, card sorting and storytelling. As single person or as a research tandem, they use adapted user-testing or the cognitive walkthrough.

Key results: People with cognitive, respective learning disabilities are no longer objects of research but rather participate jointly in the research. This concept succeeds when research partners engage with each other, when information and materials for peer researchers are available in understandable language, when enough time for explanations and repetitions and personal communication and a common consent is found. In the future, the IPAR-UCD concept which addresses peer researchers' need for support, can help software designers and developers to better meet the requirements of users with cognitive disabilities through an inclusive user-centered design process.

Conclusion: Inclusive research challenges traditional research. This design-based intervention has shown that it is possible to involve people with cognitive disabilities in R&D as testers but also as developers and idea providers.

Keywords: e-inclusion, people with cognitive disabilities, IPAR-UCD, inclusive R&D, software engineering.

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"From Word to Sign": Developing a Reading Application for Deaf and Hard of Hearing Israeli Sign Language (ISL) Users

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Background: Reading is an integral part of our daily life. For Deaf and Hard-of-Hearing people (DHH), they often face significant difficulties in this area (Convertino, Borgna, Marschark, & Durkin, 2014; Mitchell & Karchmer, 2011) As a result, this population often has a higher number of individuals with developmental language disorders (Luckner & Handly, 2008; Miller, 2010). Crucially, an impairment in this basic skill leads to negative impacts in other aspects of life (Trezek, Wang, & Paul, 2011). Numerous studies have demonstrated that access to a sign language for DHH individuals results in improved literacy skills generally, and to reading acquisition specifically (Dammeyer, 2014; van Berkel-van Hoof, Hermans, Knoors, & Verhoeven, 2016). Research of this nature led me to develop "From Word to Sign", a reading app tailor-made to this population, designed to improve reading skills for native users of sign language. The premise for this app development is the assumption that an assistive technology using sign language may significantly improve the reading of this population.
Rational: Developing "From Word to Sign" app: People with specific reading disorder can use reading software when they are confronted by an unclear word. However, for people who are deaf, this opportunity doesn't exist (reading software is not available for them). The "From Word to Sign" app enables them to compensate of their reading disability: when they face an unclear word, they can touch the word in order to operate the extension. Then they can see a short video in the sign language of that specific word that they are required to comprehend.
Test report: The application test session included five deaf immigrants aged 30–50 (three men and two women) which immigrated to Israel four years ago from France, the Ukraine, and Sweden. They were recruited for this session study through personal acquaintance with the author as their Hebrew teacher. Two-hour meetings were established with each participant, asking them to read a Hebrew text with the possibility of "recitation" and translation of unfamiliar words using Israeli Sign Language (ISL) with the app – which presents the word, its sign, and denotation. After reading the text, I asked them to sign the text in ISL.
Preliminary findings: Two participants in the pilot successfully achieved complete reading comprehension using the app while, in contrast, three achieved partial comprehension. Moreover, a review of the data from the app revealed nine areas of difficulties faced by participants: new words, words with multiple ISL translations, multi-word terms, visually similar signs with different denotations, enunciation, high-register words seldom used in daily practice, conjugations, noun modifying verbs, and visual demonstration.
Conclusion: The app should be examined and exposed to a larger group of deaf, native-born readers without additional impairments. In addition, by setting a pilot team of teachers, who teach DHH students, we will collect a wide range of findings and conclusions, in order to optimize its development. The pilot team will be responsible for updating online reading texts and will report on the effectiveness and the difficulties in using the app.
Keywords: Reading Application, Deaf and Hard-of-Hearing people (DHH), reading disorder.
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Arches Project – Validation of Technological Outcomes of Gaming Software based on a Participative Research Methodology

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Background: This paper presents a case study of software gaming development that formed part of the Accessible Resources for Cultural Heritage EcoSystems (ARCHES) Project. ARCHES is a three-year-long European Union Horizon 2020 funded project with partners within the heritage and technology sectors in four European countries. The project ends in December 2019, and uses an innovative participatory research approach to understand and address issues relating to cultural access within museums for people with sensory and learning access needs. ARCHES has three phases: *Phase 1* involves developing new technologies; *Phase 2* involves testing and redeveloping these technologies; *Phase 3* involves checking the new technolo-

gies are ready for others to use. The aim of the project is to solve barriers to learning about cultural heritage through technological solutions built through research groups. The research groups are made up of people with a range of different access preferences, are located in four cities in Europe London, Madrid, Oviedo (Spain) and Vienna – meeting on a fortnightly basis. Participants' input is collected and fed back to the technology partners, who develop and improve their chosen technology based on this information.

Method: The project is based on participatory research, informed by a social model of disability, which argues disability is a result of the way society is organised. Data is collected through fortnightly meetings during which participants' views are collected, collated and analysed with the help of the participants themselves. Therefore, the participants are treated as co-researchers. Data collection methods include voice recordings of discussions, scribed notes created for people with hearing difficulties, photographs and data records of various alpha testing and beta testing of software, and meetings with the software developers themselves.

Key results: The proposed game was introduced to the participants in March 2017. The group was presented with a rough version that set out the different challenges they were going to face. During the testing of the game three main interrelated tensions were discovered:

1. Communication within the groups, museums and technology partners, and also between each other.
2. Previous experiences with participatory research, disability, museums, games and technology.
3. Institutional restrictions such as grant restrictions and museum marketing restrictions

These tensions were faced by all parties involved in the development: participants, museum coordinators, academic researchers and technology developers.

Conclusion: Although the project is ongoing and final conclusions are yet to be made, it appears that the participatory practice has led to improvements in software design and development. However, the tensions felt between partners indicates that the methodology needs further refinement.

Our recommendation for participant research method development is that participatory groups need to be involved in the conception of future games from the earliest possible stages, rather than being introduced to the game once it has been designed in rough.

Keywords: participatory research, software development, video games, different access needs and preferences, heritage sites.

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Participatory Methodology, Inclusive Control Systems and Inclusive Technical Capital Developed by Engineering Undergraduates and Teenagers from a Marginalised Community in Mexico

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Background: This workshop reviews an education project in Monterrey, Mexico, which was designed to teach principles of algorithms and control systems and promote inclusion and accessibility in systems design – inclusive technology is defined in this project as digital systems that provide ubiquitous accessibility, with knowledge of these systems' use referred to in this context as inclusive technical capital / inclusive capital. The educational development was part of the FabLab Campana project, which was designed to encourage community innovation in Campagna, a marginalized district in Monterrey, Mexico.

Method: The methodology used to develop the participatory teaching was Grounded Methodology (GM), an adapted form of Grounded Theory (GT), and was strongly influenced by participatory methods such as those used in the EU H2020 ARCHES Project. GM encourages the evolution of interpretive deduced theories that evolve through discourse, such as educational design, the design of technology, literature searches or observational research. Participatory methodology is an emancipatory methodology, which includes all participants in the development, design and evaluation of their own inclusive practice, training and the educational process. Although this was restricted by the short time line and prescribed project proposal, the nature of participatory practice influenced the relationship with participants from Campana, whose voices were heard in the learning design. Phase 1 was teaching Tecnológico students and Campagna school students about the nature of inclusive technology and inclusive technical capital, and the use of accessible features and apps on iOS and Android. Phase 2 was

the development of discrete sessions and teaching of inclusive control systems workshops by Tecnológico students, which were influenced by discussions with teenagers from Campana. Although the design of the eventual courses was implemented by Tecnológico students, the development process importantly included the opinions of the Campana school students as part of the participatory process. Phase 3 was the delivery of the workshops to school children in Campana. Data was collected through observations of the school children, logging conversations and results recorded in writing and passed on manually and on social media from verbal feedback and recorded video and e-notes.
Key results: Phase 1: During the initial workshops, awareness was raised about what disability was and how it could be found in local households, especially the sensory impairment of elderly relatives. Some students discussed the disabilities of family members, and students also raised the issue of other forms of inclusion, including multi-culturalism and socio-economic development. Phase 2: The participants from Tecnológico and Campana designed ambitious robotic projects, but had to make their devices simpler to teach the concepts of accessible STEM and inclusion. Eventually, they developed colourful items with large pieces that could be communicated through different modes. With feedback from the Campana children, teaching sessions also included elements of geometry, sensory access needs, low-cost features to make the devices socially accessible, games and multi-culturalism. Phase 3: After teaching the workshops, the Tecnológico students discovered that logical games and participatory practice were particularly useful for teaching aspects of inclusion, and found active objects such as robots engaged children's attention and enthusiasm.
Conclusion: The long-term benefits of developing inclusive technical capital with future systems designers is unknown given the time constraints of the project, however the students and school children engaged with the notion of designing inclusive technologies, and related inclusion and control systems design. In addition, through discussion and participation, students also thought about other aspects of inclusion not considered in phase 1, that could further develop their own design of inclusive systems technologies.
Keywords: Control systems, education, inclusion, inclusive capital, grounded methodology
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Starting on the Innovation Path for a Fatigue Management App for People with Multiple Sclerosis

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Background: Fatigue is a common symptom of MS, affecting 75–95% of people, and is a major cause of reduced quality of life. FACETS is an evidence-based face to face course that combines energy conservation and cognitive behavioural approaches. It has a statistically significant impact on fatigue severity and fatigue self-efficacy. However, people with MS aren't always able to attend the multiple sessions, and, they also often have difficulty sustaining gains in the longer-term. The initial app conceptualisation came from research and practice evidence that identify the main components and goals of the FACETS programme. The starting aim was to simply replicate or substitute these components and goals adopting an evidenced-based and user-centred approach. The clinical goal is to make a usable app hence all users are being consulted via stakeholder groups to avoid users having to use poorly conceived technology during evaluations or trials.
Method: Three key steps were conducted in preparation for development, each with a specific intended output. Firstly, a systematic scoping review of literature grounding FACETS. Also identifying key components, adaptations, and any currently missing elements of behavior change. Secondly, ideation with MS professionals to capture explicit experiences and knowledge which supports, contrasts, and extends the FACETS literature. Technologists also contributed their knowhow to help specify the app concept. Thirdly, review the concept of the app and it's features in open discussion with stakeholders.
Key results: Examination of FACETS and the literature revealed: the core underlying theories include the cognitive behavioural model, social cognitive model, self-efficacy, and self-management theories; and, change in behaviour is facilitated by the use of energy conservation strategies, which include rest, sleep, healthy lifestyle, activity adaptation, and goal setting. The ideation phase was a very efficient way to simultaneously explore the design and content of the pro-

posed app. Maintaining FACETS as a facilitated course in an app produces a text heavy and screen heavy app. The authors concluded a different approach for an app was needed. One where the activities the users would engage in would still contribute to behavioral change for managing fatigue by drawing on the underlying accepted theoretical models. Further adaptations were suggested because for instance clinical practice suggests FACETS class members are resistant to the cognitive components and, opportunities to employ feedback are missing. The ideation also established that the app should be used with light touch service involvement and for self-management.

Exploring the app concept and designs with users – professional (14) and people with MS (8) – confirmed the desire for such an app. In addition to many aspirational features importantly it was found that professionals and people with MS did not agree on some key aspects.

Conclusion: A combined clinical, academic and commercial developer team using evidence-based components to develop app content, and then consulting with stakeholder groups is effective to start innovation. Despite work being preliminary, key app components have been identified which show potential to at least supplement the current delivery of the FACETS programme. Future evaluation of the app will be needed to establish evidence.

Keywords: Multiple Sclerosis, fatigue, app, innovation, user-centred.

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Special Thematic Session 3
Making STEM Accessible to Disabled People

Science, technology, engineering and mathematics (STEM) can be considered to be at the basis of modern society, making it essential that they are fully accessible to disabled people. However, relatively limited attention has been given to STEM accessibility compared to many other subjects and there are still significant barriers to be overcome. Particular issues include, but are not restricted to, difficulties in representing notation and formulae in an accessible format, reading images and graphs and making both virtual and real laboratories and field work accessible. Negative attitudes and misconceptions about what disabled people cannot do also act as barriers and concerns about health and safety issues are sometimes used as a pretext to exclude disabled people. There is also a need to avoid learning aims which cause difficulties for some groups of disabled people, such as being able to draw graphs on paper rather than analyse the results of graphs produced by software. This session will discuss the full range of issues associated with making STEM accessible, with a particular focus on the role of assistive technology and tools designed to support accessibility.

Chairs: *Marion Hersh and Barbara Leporini*

Natural Language Processing for Non-visual Access to Diagrams

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Background: Current accessible alternatives to diagrams for blind persons pose many critical drawbacks hindering their take-up, to the point where appropriate access to diagrams has been labeled as “the last frontier in accessibility”. Dialogue-based approaches to graphics, in which users communicate with the image via speech, are a novel area of research whose evaluation has yielded very promising results in overall expressivity and user satisfaction.

Method: An accessible Web application prototype implementing a natural language processing (NLP) pipeline to semantically annotated diagrams has been designed. Diagrams are first given formal semantics via supporting ontologies that may be embedded within the graphic itself by using SAI (Semantic Annotator for Inkscape), an authoring tool for semantically-enhanced graphics. The resulting ontologies may then be explored by a blind user by means of speech in a natural manner via queries in natural language on a fully accessible Web application. The presented method expands on previous publications by the authors by focusing on the specific NLP techniques employed. Some of these techniques include:

Automatic inference of analytical tasks and operands from a user’s query in natural language through ontologically-motivated heuristics.

Use of automatic clarification dialogues where users are asked to interpret ambiguous or unknown elements found in their query.

Presentation of the result or lack thereof to the user.

Support for non-visual navigational tasks of graphic primitives through speech commands.

Bookmarking of graphic elements and other methods that contribute to preventing overloading the user’s

working memory while using the natural language interface (NLI).
These techniques mostly stem from state-of-the art research in dialogue interfaces to ontologies that we have expanded and adapted for their use in accessibility. We also demonstrate the integration of techniques that adapt the NLI to the specific needs of blind users, as most current research on NLIs does not focus on accessibility.
Key results: This submission deals with the novel research question of how to enable dialogue-based access to diagrams, and it is the first of its kind we have been able to find in the literature. Heuristic evaluation of our methodology has shown that NLIs are a satisfactory approach to non-visual access to diagrams, their key advantage being the lack of necessary previous training of the users and that it requires no extra software or hardware besides what blind Web users are accustomed to employ for surfing the Web.
Conclusion: Our research shows how natural language interfaces are a promising novel approach to non-visual accessibility of diagrams. We hope that the proposed NLP pipeline will be exploited by other authors fostering future research in accessibility to visually displayed STEM materials.
Keywords: Non-visual diagrams, natural language, accessibility.
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Technology Support for Inclusive STEM Laboratories: State-of-the-Art and Open Challenges

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Background: This research is motivated by the importance of science, technology, engineering and mathematics (STEM), including for many careers, understanding increasingly important public debates and policy formulation on issues such as cybersecurity/privacy management and genetically modified organisms and for personal life e.g. budgeting. STEM accessibility seems to have received less attention than that of other subjects. Particular areas of difficulty/exclusion are laboratories, fieldwork and access to formulae. This presentation will focus on laboratories.
Method: There are three main components:

1. A review of the literature.
2. An examination of the authors' previous work.
3. An evaluation of the issues drawing on the authors' experience as disabled people working in STEM.

Key results: The relatively limited literature dating back to at least the 1980s recognises that disabled students require similar laboratory experiences to other students and that disabled people do not raise particular safety issues despite the use of health and safety considerations as a pretext to exclude them. Both design for all and adaptations for specific individuals and people with particular impairments are required. The former includes an uncluttered layout, wide aisles, good signage, adjustable height tables and seating and commonly used equipment close together. Demonstrators and technicians should have training in working with disabled students and staff and in supporting particular disabled students.Both the increasing capabilities of technology and the role of assistants have been noted. However, technology can support a more independent lab experience. The use of remote computer controlled labs and virtual simulations have been suggested, but should not replace physical lab accessibility. Accessibility of this software can be improved by text labels, keyboard access, personalised settings and auditory feedback, which should have an 'on/off switch'. However, challenges are still available for working remotely and effectively with certain experiments, such as to get back information on what is happening, or on the colour or reaction of particular substances. Talking lab probes were introduced in the 1980s, but not mass produced due to cost. More recently, free script files have been developed to make Vernier lab probes compatible with the JAWS and Window Eyes screenreaders to allow real time access to data by blind and dyslexic people. A handheld computer with screenreader has been developed as a portable data collector. Light microscopes have been made accessible to physically disabled users through a remote viewing web-based application. Mounting a video camera can avoid the need to use the eyepiece. A motorised microscope with an automatic load slider can be used by physically disabled and low vision users. Low-tech adaptations, including easy-grip handles, lower seating and 3D tactile models, could benefit all laboratory users.
Conclusion: Technology has considerable not fully tapped potential in improving lab accessibility. Initial work could focus on:

– Developing a wide range of equipment with speech output and screenreader compatibility.

– Developing precision robot manipulators compatible with a range of equipment which can carry out manual operations and be operated by various assistive devices.
– Using adjustable-height benches and equipment, easy-grip devices, tactile models.

Keywords: STEM, lab accessibility, accessible equipment, low tech adaptations, assistive devices.
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InftyReader Lite: Converting e-Born PDF into Various Accessible Formats

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Background: One of the most serious problems in digitized STEM (science, technology, engineering and mathematics) contents, which are usually provided in PDF, is their poor accessibility. From the viewpoint of computerized processing to convert PDF into an accessible form, PDF can be classified into two types. "E-born PDF" is produced originally from an electronic file such as a document in Microsoft Word, LaTeX, Adobe InDesign, etc. (without copy protection). We refer to all the others as "image PDFąőąŕ. The most significant advantage of e-born PDF is that the information on each character/symbol such as its character code, font type, coordinates on a page is embedded in it.
In ICCHP2016, we reported a method to recognize STEM contents in e-born PDF, in which character information extracted directly from a document was combined with analysis technologies of Mathematical OCR (optical character recognition). It was very effective; however, in the inside of mathematical formulas, a font rectangular-area extracted from e-born PDF by a PDF parser often differs significantly from the graphical area of the original character image. Thus, it cannot be used for mathematical-structure analysis as it stands. To correct that, we still had to use OCR engines in our STEM-OCR software, "InftyReader".
Method: We have recently adopted a new powerful PDF parser that also provides us with "vector-image information" for printing characters/symbols. Using it, we can get the true graphical area of the original character image even in the inside of mathematical formulas. It allows us to develop new software, "InftyReader Lite (IRL)" that does not need any commercial OCR engines for recognizing STEM contents in e-born PDF. Since its recognition process no longer depends on image OCR, accurate conversion into text and mathematical-structure analysis can been done even if characters/symbols have color ornaments or a background image.
Key results: IRL can recognize just e-born PDF; however, IRL can convert it into various accessible formats as same as the standard version of InftyReader. That is, a recognition result can be exported in IML (the original xml in Infty software), LaTeX source, XHTML with MathML, MS Word, Multimedia DAISY ("Digital Accessible Information System": an international standard format for accessible e-books), accessible EPUB3, "ChattyBookąőąŕ, "PDF with TeX", etc. Here, ChattyBook is audio-embedded HTML5 with JavaScript which can be read with a popular browser on various platforms (Internet Explorer, Chrome, Fire Fox, Safari). ChattyBook has the almost-same functionality and operability as DAISY. In Japan, many multimedia-DAISY textbooks are now converted into ChattyBooks, and thousands of print-disabled students (mostly ones with developmental reading disorder) use them. PDF with TeX is a new-type of accessible PDF, in which text information is embedded, in actual reading order, in the background of the original-PDF page image. Mathematical parts are represented in LaTeX, and it is totally accessible for print-disabled people to read STEM contents with a screen reader.
Conclusion: IRL should be a good/low-cost solution for print-disabled people to convert (inaccessible) STEM contents in e-born PDF automatically/easily into various accessible formats.

Keywords: e-born PDF, accessibility, conversion, DAISY, STEM
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An Investigation into Pedagogical and Opportunity Barriers in STEM Education of Visually-Impaired Nigerians: Why Disabled People Must be Involved

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Background: Access to labs and field work are further barriers to STEM. Health and safety considerations are often unjustly used to exclude disabled people from practical work. in Nigeria, a West-African country, the exclusion transcends industrial-hazards as visually impaired individuals are denied access to STEM education and by extension laboratory and field-oriented professions. While unavailability of standardised notations, inappropriate resources, unsuitable teaching strategies, and lack of visually impaired STEM professionals who could serve as role-models have been found as barriers to STEM career of visually impaired persons, nonetheless, the exclusion remains unabated. It is against this background that the pedagogical and opportunity barriers in STEM education of visually impaired learners were investigated. To achieve the objectives of the study, the following research questions were raised: What are the barriers to STEM education of visually impaired learners? What opportunities do visually impaired learners miss as a result of these barriers? And How can these barriers be eliminated?
Method: Informed by the popular disability mantra "Nothing about us without us", the researcher sought a true and general representation of actual experiences of visually impaired persons. Ethical approval was obtained from executives of Light for the Blind People, Nigeria who helped in seeking their members' consents to participate in the research. Descriptive survey design was adopted. Study population was made up of visually impaired students from 36 states of Nigeria and the Federal Capital Territory. Using nonprobability or non-random sampling technique, a total of 401 participants who attended the annual meeting of the association was conveniently and purposively selected for the research. Out of the 401 copies of the closed-ended structured questionnaire that were administered, only 380 were found usable. Data collection and analysis were conducted within three weeks. Four-type Likert scale was used, and mean scores were calculated for data analysis.
Key Results: The study revealed that: visually impaired students face barriers to STEM education due to stereotypes revolving around their capabilities (2.93); barriers to STEM subjects limited their educational and career opportunities (2.52); well-defined notations can eliminate these barriers (3.14).
Conclusion: Although, these results are specific to Nigeria, in general, disabled people are misconceived and excluded from practical-oriented education and professions in both developed and developing countries. It is therefore concluded that a lot of work is required to change social negative attitudes towards visually impaired persons as provision of standardised notations can only help in reducing the barriers. Recommendation was then made that further work is needed to remove the barriers that prevent disabled people from accessing laboratory and field works.
Key words: Pedagogy, Barriers, STEM, Visually-Impaired-Persons, Nigeria.
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Robot-supported Inclusion and Learning: A Case Study on the KUBO Robot in Early Childhood Education

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Background: The presence of educational robots in preschool and early primary school settings is getting stronger and has shown to have powerful playful qualities and to support learning. Research within socially assistive robotics in education suggests embodied robotic technology may facilitate social engagement and support inclusion, however little research has been conducted on whether the act of programming social robots may play an important part in discovering and designing for diversity in play and learning. This paper presents findings from a case study on the educational robot KUBO in Denmark and proposes a participatory and practice-based approach to the design of robot-supported learning aimed at the transition between preschool and primary school. The purpose is to support and empower children's essential life skills including imagination, collaboration and communication skills and to provide pathways capable of detecting and including a diversity of children's needs and skills in a more advanced way than currently offered by traditional educational technology.
Method used: Kubo is a mobile robot developed by Danish startup company Kubo Robot, designed to support learning for children in early primary school in various subjects such as coding, language, and music through a tangible coding language; TagTiles. In the case study, teachers and pedagogic professionals co-developed robot-supported learning designs with KUBO and tested these in three different scenarios; math teaching in 2nd grade, play-based learning in kindergarten as well as a 'transition' experiment in

which 2nd grade students were teaching young children (age 5–6) how to code using KUBO. Data included four instances of participatory observations, interviews with the teacher and pedagogic professionals as well as in-situ interviews with children.
Key results: The case study provides valuable insights into inclusive practices applied when implementing robot-supported learning designs (e.g. using a storytelling approach to facilitate computational thinking and understanding of coding concepts or applying peer-to-peer learning to empower children with learning disabilities), however, new potential inclusive practices also emerged from experimenting with the robots. For instance, a child's individual experimentation with programming in ways very different from his peers (e.g. applying engineering methods) turned out to reveal different skills but also needs, which may support more diverse approaches not only to the technology, but to learning in general.
Conclusion: Findings from the case study indicate that the application of robot-supported learning designs may support the visibility of children's diverse needs, skills and interests and facilitate the emergence of new inclusive practices. However, further research is needed to develop systematic approaches to inclusive robot-supported learning designs and to quantify its effects in practice, particularly in transitions between preschool and primary school.
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Automatic Support for Web Accessibility Evaluation

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Background: Designing for people with disabilities is becoming an increasingly important topic for several reasons. Accessibility has become necessary due to the rapid growth of online information and interactive services provided by web and mobile applications. The recent European Web Accessibility Directive (WAD) promotes the rights of disabled people and requires consistent monitoring of accessibility in public websites.
Even if the accessibility validation process cannot be fully automated, in order to support accessibility, it becomes important to have validators able to check, automatically or semi-automatically, the correspondence between the requirements of accessibility guidelines and the characteristics of the Web pages under consideration. These tools are useful for those involved in developing websites, as through them designers and developers can easily and quickly check whether their work meets the considered accessibility requirements.
Method: We have carried out an analysis of the state of art in the area of accessibility validation tools and elicited feedback of stakeholders working in public organizations with online surveys and interviews. We thus found some common issues. Expandability and upgradeability: newer technical guidelines get released, and while there is one international standard (WCAG), some countries make modifications to it. For the developers of validators, extending the set of guidelines supported by their tools can be a major undertaking. Alignment with the latest technology: in the ever changing panorama of technologies, the first generation of validators often appears to be unable to effectively validate websites made with the most modern technologies. Limited effectiveness of the reports: people with different roles (developers, designers, public officers) need reports containing different information for improving the site.
Key results: We have designed and implemented a new version of the MAUVE validator, available at https://mauve.isti.cnr.it/, aiming to address the issues identified. Guidelines are specified through an XML-based language, and externally stored, so that they can be easily updated to include new guidelines. Therefore, we have specified the new success criteria introduced with the WCAG 2.1 guidelines by using such language, so that the tool can support the validation against the latest standard. It has the ability to validate various device-specific versions of a website, and dynamic websites validation through browsers' plugins. It can provide the validation report in the EARL W3C standard format, ensuring consistent interpretation of results. It also provides developers-oriented report system, with indications of the accessibility problems directly into web page source code. The public version of the tool supports validation of web pages provided by URI or local files or direct HTML input. We have also an internal version able to support the validation of entire websites and providing a more graphical report, oriented to non-technical users.
MAUVE will also be integrated in a large-scale accessibility assessment infrastructure (under development in the EU WADcher project), which includes advanced decision support tools, and a web accessibility observatory.
Conclusion: Validators are fundamental in making the validation process more efficient, consistent, reliable

and cost-effective. We present an accessibility tool for the main stakeholders (web commissioners, web developers, ...) and discuss its potentialities.

Keywords: accessibility, automatic accessibility evaluation, WCAG 2.1, guideline specification.

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Special Thematic Session 4
Appropriate Wheelchairs, a Global Challenge – Reflect, Review, Strategize/Revolutionize

Appropriate wheelchair and seating assistive technology is often essential for people with mobility impairments' health and wellbeing. While some progress has been made, evidence suggests that despite the World Health Organization's Guidelines on wheelchair provision, training packages and other resources, getting 'the right wheelchair' remains a global challenge with provision being focused around just delivering the product instead of following an evidence-based service process. In addition, many governments have not committed to national wheelchair provision policies. Several authorities employ ad hoc, unsustainable systems instead of providing accessible person-centered services, skilled personnel, quality products, maintenance, follow up and management. Sustainable wheelchair service provision infrastructure is required from a human rights perspective.

In January 2018, USAID, World Learning and the International Society of Wheelchair Professionals (ISWP) facilitated a wheelchair stakeholders meeting hosted in Bangalore, by Mobility India. Bringing together fifty six sector leaders to share perspectives and consider future developments, the goal was to establish key priorities for the next five years to strengthen wheelchair services through policies, trained personnel and a range of appropriate wheelchairs. To achieve this goal, ten priority actions were identified to effect change towards sustainable development.

This session discusses global challenges faced and actions needed from multiple viewpoints. The importance of appropriate wheelchair provision will be illuminated by real world accounts. Collectively reflecting on ten years of development in research, education, and service delivery, the panel will review the current situation, progress made and discuss ways to build awareness towards action which will revolutionize wheelchair provision globally.

Chair: *Rosemary Gowran*

Wheelchair Stakeholders Meeting 2018 – Developing a Global Wheelchair Sector Report with Priority Actions Toward Sustainable Wheelchair Provision: Appropriate Wheelchairs, a Global Challenge

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Background: Since 2002, USAID has invested in the wheelchair sector with the goal of improving mobility and opportunities for people with mobility impairments in low and middle income countries. Investments have evolved over the years, from specific organizational earmarks to country-based and global investments in resources, policy promotion, procurement and standards. In 2006 USAID along with WHO and ISPO held the Wheelchair Consensus Conference to identify best practices for improving access to wheelchairs. As a result WHO published the Guidelines on Providing Wheelchairs in 2008 which highlights Design and Production, Service Delivery, Training and Policy and Planning as fundamental elements of the ecosystem. As a result of the Guidelines USAID made several global investments. In 2012 USAID along with World Learning (WL) and Management Sciences and Health (MSH) convened stakeholders to reflect on past learnings and identify sector priorities which were:

- Create a global initiative for greater collaboration and coordination to lead awareness raising, knowledge sharing, data collection and research, and ensure appropriate wheelchair service provision;
- Engage governments and other partners to support access for appropriate wheelchair service provision and get wheelchairs and other mobility devices on essential medical device lists and framework for Universal Health Coverage;

– Develop mechanisms to maintain quality standards for products, services, providers, and training in wheelchair service provision.

Acting upon the recommendations, USAID made several investments, including support for the development of the International Society of Wheelchair Professionals (ISWP); the Global Cooperation on Assistive Technologies (GATE) initiative; and the Consolidating Logistics for Assistive Technology Supply and Provision (CLASP) activity. In 2018 USAID along with ISWP and WHO brought together stakeholders to reflect on the three key investments identified in 2012 and define key sector priorities for the next five years.

Method: The main method was hosting a facilitated meeting to develop a challenge model. The challenge model leads participants through a process to define key challenges, strategic priorities, measurable results, obstacles and root causes and priority actions for the selected challenge.

Key results: As a result of the meeting and a post meeting advisory group Wheelchair Sector report was completed including a five-year Sector Goal and Priority Actions

SECTOR GOAL

By 2023, 10 countries have new or strengthened evidence-based, adequately-resourced, integrated wheelchair services supported by policies, competent personnel, and a range of appropriate wheelchairs.

PRIORITY ACTIONS

1. BUILD AWARENESS
2. CONDUCT RESEARCH
3. ESTABLISH GLOBAL SERVICE STANDARDS
4. ESTABLISH PRODUCT STANDARDS
5. FOSTER INNOVATION
6. IMPROVE WHEELCHAIR SUPPLY
7. PROMOTE POLICY
8. STIMULATE COLLABORATION
9. SUPPORT COMPETENCY DEVELOPMENT
10. SUPPORT GOOD PRACTICE

Conclusion: Utilizing the results identified USAID along with several donors have been making investments to implement the priority actions related to improved wheelchair access and service were identified. Several of the priority actions are now in implementation and others are being more thoroughly defined through an analysis by ATscale, a Global Partnership for Assistive Technology. Under this partnership investable interventions are being defined for donors which build off the results of the stakeholder meeting. Additional interventions are being defined for hearing aids, eyeglasses and prosthetics.

Keywords: wheelchair, global, strategy, stakeholders, Bangalore, standards.

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Personal, Public, Political Discourse Illuminating Context Specific Experiences Enabling and Depriving Individuals as Wheelchair Users in the Republic of Ireland: Appropriate Wheelchairs a Global Challenge

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Background: Providing an appropriate wheelchair is complex and challenging due to diversity of people, places, provision processes, personnel, procurement and the existence of relevant policies. An inappropriate wheelchair can impact severely on a person's health and wellbeing. The importance of developing sustainable wheelchair services continues to be undervalued. This paper illuminates the perspectives and experiences of wheelchair users in Ireland, reflecting personal, public and political discourse since the introduction of the WHO guidelines on the provision of manual wheelchairs in less resourced settings in 2008.

Method: Mixed methods were used: *National online survey* using SurveyMonkey$^{\mathrm{TM}}$, exploring wheelchair service user's experiences and level of satisfaction with wheelchair and seating provision in the Republic of Ireland. *Individual semi-structure interviews* exploring wheelchair service user's personal perspectives. *Scoping review* exploring the public and political discourse on wheelchair provision in the Republic of Ireland from 2008–2018.

Key results: *Survey results* ($n = 273$) show high weightings of satisfaction across the service delivery process, yet 38% of respondents ($n = 105$, 38.5%) did not feel their wheelchair meet their needs. Results indicate ad hoc waiting times and funding streams, with a lack of uniformity at each stage of the process. Over 30% of respondents reported receiving little or no ed-

ucation and training skills. Follow up within the first six months of receiving their wheelchair product was limited (21% $n = 48$, of respondents $n = 228$); with only 41% ($n = 95$) needing wheelchair repairs satisfied with this service. *Individual interviews* ($n = 18$) reflect similar disparity. The importance and embodied nature of the wheelchair was clear, with poorly prescribed wheelchairs affecting a person's life, their physical (pressure injuries), mental (vulnerability and underlying fear) and social (engaging in the community) health. The experience of service delivery was influenced both positively and negatively by a person's relationship with personnel, including occupational therapists and sales/ vendor representatives, disputing the client centered nature of interactions and outcomes. The provision system was hard to navigate with a continuous fight to get the right wheelchair and follow up services to support this.

The *Scoping review* indicates a challenged wheelchair service within the public and political domain, highlighted in scientific published ($n = 3$), unpublished ($n = 2$) papers, questions to Minister of Health ($n = 22$) and newspaper articles ($n = 21$). Four themes emerged: *personal* lived experience of wheelchair users and their families, with stories relating to children predominant; *political* discourse reporting constraints within the system and a call for national policy; *provision* system processes were poor, with wait times having an overwhelming effect on individuals; and *place* highlights inconstancies across the country, with Dublin, Cork and Limerick reported on most frequently.

Conclusion: The significance of a wheelchair in person's life cannot be denied, yet there is a lack of clear transparent pathways, protocols and policy for wheelchair service provision to meet individual needs. Disparity exists throughout the wheelchair provision process, with many clients left waiting or fighting for their wheelchair. This work strengthens the call for a national review of wheelchair services in Ireland, with government commitment towards sustainable development as a matter of urgency.

Keywords: Appropriate Wheelchair, Service Delivery, Experiences, (Irish Context), (Disparity).

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Global Wheelchair Service Provision Capacity Building: An Online Mentoring Feasibility Study

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Background: Evidence highlights that a major factor associated with inappropriate wheelchair distribution is the global shortage of wheelchair service provision education and training. The World Health Organization Guidelines on the provision of manual wheelchairs in less-resourced settings (WHO Guidelines) recommend integrating wheelchair service provision content into existing rehabilitation programs at academic institutions... However, a 2017 study reported limited training time allocated to wheelchair service provision in some professional rehabilitation programs in low-middle- and high-income countries. To help assess the global training need, the International Society of Wheelchair Professionals (ISWP) developed and validated a Wheelchair Service Provision Basic Test (Basic Test) which aligns with the WHO Guidelines' eight (8) wheelchair service provision steps. Currently, in the majority of regions where the test has been applied, less than half of test takers pass the test with 41% passing in Africa, 44% in Asia, 46% in Latin America, 47% in Europe, 48% in Australia and Oceania, and 55% in North America, which confirms the overwhelming need to promote training and continued professional development and mentorship of wheelchair service providers worldwide. Novel flexible capacity building activities are needed to help address this need. Thus, this study addressed the following research question: *Is it feasible to implement an online mentoring program for wheelchair service providers globally?*

Method used: Fourteen intermediate wheelchair service providers enrolled in a feasibility study of an 8-week online Intermediate Level Mentoring Intervention, led by 3 experienced mentors. The program consisted of 9 tutor sessions led by mentors focusing on topics relevant to intermediate level wheelchair service provision, 5 case study sessions (mentees presented real service provision case studies and received feedback from mentors), and 3 individual meetings with mentors to clarify concepts and provide individual coaching. A goal attainment plan was created for each mentee by the mentor-mentee pair. All interactions were hosted in the Adobe Connect platform. Pre-post self-efficacy measures in intermediate level seating were taken by all mentees as well as a program satisfaction survey and focus group after participation.

Key results: The project findings indicate adequate results across all feasibility components (recruitment

(100%) and retention (50%) rates; perceived benefit (85% participant satisfaction); and adherence rate (71%). Improvements in clinical reasoning on case studies were also observed by mentors. Pre-post improvements in self-reported self-efficacy and goal attainment were noted. Satisfaction survey and focus group data showed overall satisfaction with the intervention and provided recommendations for improving future program iterations.

Conclusion: An online mentoring program for intermediate level wheelchair service provision is a feasible intervention for a subset of intermediate wheelchair service providers and may improve providers' goal attainment and self-efficacy in intermediate level wheelchair service provision. An experimentally controlled study is a recommended next step to determine how an intermediate level wheelchair service provision online mentoring program improves providers' competency.

Keywords: wheelchair service provision, mentoring, professional development, education, capacity building

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A Cross-Sectional Survey Investigating Wheelchair Skills Training in Ireland: Appropriate Wheelchairs, a Global Challenge

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Background: Wheelchair skills training is a vital aspect of wheelchair service delivery, yet they are arguably overlooked in many contexts. Training can contribute to the prevention of pressure injuries and fall-related injuries, empowering users and improving health and wellbeing. The practice of wheelchair skills training provided to wheelchair users by Irish clinicians is highly variable. This paper presents the results of a study exploring wheelchair skills training practice among Irish clinicians.

Method: A cross sectional survey was conducted using SurveyMonkey^{TM}. Invitations were sent to associations and special interest groups known to employ professionals involved in wheelchair service delivery (e.g. Occupational Therapists, Physiotherapists, Rehabilitation Engineers). Questions related to wheelchair skills trainings offered to wheelchair service users, wheelchair skills components included and nature of clinician's education and training to provide training in wheelchair skills. 147 respondents opened the survey and 91 responses were received from occupational therapists and one rehabilitation engineer. Quantitative data were combined, and summary statistics were carried out, when appropriate, using SPSS Statistics (i.e. frequencies, proportions, and cross-tabulations). Qualitative responses were inputted into an Excel spreadsheet and a content analysis was carried out.

Key results: Consensus among respondents was that training is often provided to new users ($n = 91$, 89%), however, it is limited to mostly instruction in transfers and simple mobility techniques. Clinicians reported that advanced mobility skills were sometimes or never taught ($n = 81$, 72%). Clinician's confidence instructing various skills corresponded with the frequency of instruction. Clinicians reported that they would like to see standardized training programs established in self-maintenance and advanced wheelchair skills.

Conclusion: The results indicate a need to further develop wheelchair skills training delivered by occupational therapists and others. Formalized education and training to improve Irish clinicians' knowledge and confidence to provide more advanced wheelchair training is needed. More streamlined wheelchair skills programmes would teach users about safer wheelchair use, while enhancing health and wellbeing and greater occupational participation.

Keywords: Wheelchair skills, Wheelchair skills trainings, Occupational Therapy.

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Improving Global Wheelchair Product Quality

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Background: In 2008, the World Health Organization published Guidelines of the provision of Wheelchairs in Less Resourced Settings (LRS) which emphasized the need for all wheelchairs to meet standards pub-

lished by the International Standards Organization and for the standards to be adapted to the adverse conditions common in LRS. This guidance was in response to the widespread distribution of poor-quality wheelchairs in LRS that failed quickly and left the rider stranded and/or injured. In spite of the WHO's authority and influence on global practices, wheelchair quality has not improved significantly, nor has the ISO standards been adapted. The work described here was to help implement WHO's recommendations to improve overall wheelchair quality globally and eliminate the distribution of inferior quality wheelchairs.

Method: A working group of wheelchair experts familiar with ISO testing and wheelchair design for LRS was established in 2015 by the International Society of Wheelchair Professionals and was tasked with helping to implement WHO's recommendations by identifying and prioritizing the tasks associated with improving wheelchair product quality in LRS. Following this activity, the highest-priority tasks were carried out by working group members.

Key results: Working group members included individuals from universities (University of Pittsburgh, LeTourneu University, Massachusetts Institute of Technology) and non-governmental organizations and Charities (ShonaQuip, LDS Charities, Motivation Charitable Trust). Priorities identified by the group included (1) the need for a best-practices guideline on wheelchair design (2) the need for a caster durability test method, (3) the need for a rolling resistance test method, and (4) the need for a whole wheelchair testing system. All four of these priorities have been accomplished, leading to multiple publications, open-source materials to support improve wheelchair quality, increased testing capacity, and test-results which have led to improved products.

Conclusion: Through a global collaboration and coordination of the wheelchair sector, major progress has been made toward implementing WHO's recommendation. The outcome has led to tangible tools for the wheelchair sector to leverage to improve product quality, and better collaboration across global partners to help implement WHO's recommendations.

Keywords: wheelchair, product standards, less resourced county

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On Tire Pressure and Comfort of Manual Attendant-Controlled Wheelchairs

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Background: For physically impaired persons, the wheelchair is indispensable travel means. However, wheelchairs may cause motion sickness or discomfort and annoyance due to vibration when moving. In particular, the tire pressure affects when traveling over a level difference. The most commonly used English-style valve for wheelchairs can insert air into the tire but cannot adjust the air pressure. Therefore, it is unclear how the wheelchair tire pressure affects the vibration. This research evaluates the influence on vibration due to changes in tire pressure of the manual wheelchair, using a tire pressure indicator suitable to the English valve.

Method: A dummy heavy load was placed on the seat of a manual wheelchair to assist the vibration measuring device manufactured in this experiment, and a triaxial accelerometer was attached thereon. Also, an electric wheelchair was run a road surface with irregularities at constant speed and constant intervals. A tire pressure indicator manufactured for this study was attached to both sides of the rear wheel of a manual wheelchair, and a 25 kg dummy heavy load was placed on the seat section. The tire air pressure was set to 80 kPa, 160 kPa, 240 kPa, and 320 kPa. Next, a sensory evaluation of riding comfort was carried out. Evaluation items were set to 4 items, in addition to the three items of comfortable feeling, comfortable feeling and seating comfort of the buttocks, and the strength of the shaking during traveling, both at rest and running. The experiment was conducted with the cooperation of 10 subjects. The average age of the subjects was 21.9 years.

Key results: FFT analysis was performed on the acceleration data measured in the vertical direction. From the results, comparison was made between each tire pressure and the maximum power spectrum of the manual assistant wheelchair and the frequency at the maximum power spectrum were compared. Experiment results revealed that the maximum power spectrum increases as tire pressure increases. As a result

of the significant difference judgment, there was a significant difference between the maximum power spectrum and the frequency at the maximum power spectrum when the pressure of the tire air pressure was separated by 160 kPa. Although there was no difference due to the difference in air pressure between the seating comfort at rest and the security, it was found that lower tire pressure increases sitting comfort, which becomes worse at the higher air pressure. The result when traveling was that, for all items of comfort, seating comfort and the intensity of shaking, the tendency was higher as the tire pressure decreased. In particular, the three items of sitting comfort, sense of security and strength of shaking showed strong significance levels.
Conclusion: It became clear that the tire pressure and the maximum power spectrum of the wheelchair, the frequency at the maximum power spectrum, and the integral value are proportional. A significant difference was observed when the tire air pressure was 180 kPa away from the maximum power spectrum and the frequency at the maximum power spectrum. When running, the result that the ride comfort decreased as the tire air pressure increases, but in general, the driving force decreases as tire pressure increases, so there is a trade-off. In the stationary state, the lower the tire air pressure, the higher the comfort. In nursing homes and other facilities, it is suggested that air pressure is must be adjusted with someone sitting in a wheelchair for a long time.
Keywords: Wheelchair, Tire pressure, Traveling over a level difference, Vibration, sensory evaluation.
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Special Thematic Session 5
Eye gaze technology: accessibility, usability and effect on participation and communication for persons with severe disabilities

This session presents latest research findings and lessons learned from an international interventions study and a total survey involving eye gaze technology users in all ages. The speakers, researchers and clinical practitioners, are from Sweden, Dubai and USA. First findings from a total survey study in Sweden reporting on accessibility, usability and different aspects of eye gaze technology usage in everyday life will be presented. The users were in all ages, (171 users, 4–81 years) with diagnoses such as cerebral palsy, Amyotrophic lateral sclerosis (ALS), Rett syndrome, and multiple sclerosis (MS). Differences between children and adult users (diagnosis, accessibility, daily usage, and usability), and which users seem to benefit the most from eye gaze technology provision will be reported. Next, research findings and lessons learned from an international intervention study will be presented. Children with complex needs that were provided with eye gaze technology were followed over time and measured both with and without the assistive device. Active participation in activities, functional independence in everyday life and communication behavior with and without eye gaze technology as well as guidelines for clinical practice will be discussed. The session provides in-depth knowledge and outcomes of how eye gaze technology can contribute to everyday life for people with severe disabilities. The session also includes experiences in the application of eye gaze technology in clinical practice. The audience will have the opportunity to share experiences of eye gaze technology and participate in a discussion of how research findings may benefit clinical practice.
Chair: *Helena Hemmingsson*

Eye Gaze Controlled Computer: A Total Survey in Swedish Context

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Background: Eye gaze controlled computer (EGCC) is an assistive device (AT) that provides people with profound physical impairments opportunity to control a computer with eye gaze and by that communicate and participate in the digital world as well as in society. Few people have access to EGCC and existing research is scare, typically focus on a single diagnosis, either adults or children and include few persons. This research includes all EGCC users in Sweden in order to investigate which groups that receives EGCC as an AT, in what activities it is used, the effectiveness of the AT and users' perception of usability in everyday life.
Method: Design: Total survey. Assistive technology centers in Sweden identified all inhabitants with a prescribed EGCC and mailed them (if < 18 years old, the parents) a questionnaire. The questionnaire comprised 1) person characteristics 2) eye gaze technology usage (settings, activities, duration, frequency, effectiveness and efficiency) and 3) satisfaction with device and

related service. Descriptive statistics, non- parametric and parametric analyses were performed to describe the whole sample and to make comparisons between adults and children ($<$ 18 years old).

Key results: The questionnaire was answered by 111 adults and 60 parents (child version), response rate 42%. No significant differences between respondents ($n = 171$) and non-respondents ($n = 232$) were found. The participants' ages ranged between 4 and 81 years with the majority in school or working age (mean 40 years, sd 19.7), 49% were females. Most common diagnosis was Cerebral palsy (CP) among children (76%) and ALS (26%) among adult users. The time for accessibility of EGCC ranged up to eight years with a mean time of 2.0 years (sd 1.7). For most (79%) eye gaze was the only option to control a computer and nearly all (93%) used Tobii products. Sixty-three percent had daily usage of eye gaze technology while about one third had weekly usage (33%), or less often (4%). Overall, participants are quite satisfied with the eye gaze technology as an AT.

More adults (45%) than children (18%) used EGCC 2 hour or more/day during leisure ($p < 0.01$). A few, three children (5%) and 17 adults (16%) had usage for more than eight hours per day. Most children (82%) used EGCC in school and most common up to 2 hours/day (57%). Adults, to a higher extent than children ($p < 0.01$) thought they could use the EGCC in as many activities as needed (59/31%) and as often as needed (65%/38%) ($p < 0.01$). The activity repertoire by EGCC ranged up to 12 activities (m 4.8, SD 3.0). Most common activities for adults were to write (67%) and to 'to talk' (62%), while the most common activities among children were 'play and games' (74%) followed by 'to talk' (72%). EGCC was seldom used for environmental control by children although parents rated it as very important.

Conclusion: EGCC is used in all ages and both at school/work and during leisure. Daily usage was moderate although very high for a few. Overall, adults had higher use and were more satisfied with their usage than children. The full potential of applications in particular for children can be improved.

Keywords: Digital access, Children, Adults, Eye gazing.

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Eye Gaze Technology for Children with Severe Multiple Disabilities: Parents and Professionals' Perception of Gains, Obstacles and Prerequisites

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Background: Children with severe multiple disabilities are a heterogeneous group. Their problems may entail both motor and cognitive dysfunction and they typically have difficulties within all areas of activities and depend on an adult to assist them in order to play, communicate and perform any other daily activities. In some cases, eye movement is the only body movement a child can control voluntarily. As a common AAC method for these children is eye pointing (the communication partner follows the child's direction of eye gaze in order to understand his or her intention), use of eye gaze technology is interesting. However, it is both time consuming and requires specific competence to assess and introduces eye gaze technology and to prepare functional software grids for children with complex communication needs, severe motor and cognitive disorders. There is a need for more knowledge of how and for what the children use their systems, and factors that should be considered.

The aim of this study was to explore parents' and professionals' thoughts of how a gaze-controlled computer can be beneficial to children with severe multiple disabilities. A further aim was to investigate factors affecting usability.

Method: The participants were 11 parents and professionals, each of whom had taken on the role of key person in the work with a child using eye gaze technology. The systems were provided primarily for symbol-based communication but were also used for other purposes such as play, leisure and school activities. An interview guide was designed with open questions concerning important factors facilitating use and problems encountered, and also questions concerning what the child was able to do with the technology. The interviews were recorded and transcribed. The study was analysed with Content analysis, which is described as a flexible method for analysing text data.

Key results: The analysis process resulted in three categories and twelve subcategories. The children used

eye gaze technology for a variety of activities. There were gains for the children in terms of empowerment, social interaction, learning opportunities and efficient computer use. The informants mentioned that it increased the children's ability to perform activities independently, express themselves and show competencies. Inaccessibility, liability issues and technical failure were seen as obstacles, while prerequisites included time, collaboration, stimulating content, know-how and opportunities.

Conclusion: This study suggests that eye gaze technology can provide children who have multiple disabilities with new opportunities to communicate, interact and perform activities independently, if conditions are right. The results indicate that certain prerequisites such as time spent, expert support, collaboration within the closest circle of people around the child, and stimulating content are necessary to make the technology useful and sustainable. The validity of the study might be affected of the small number of informants. We did not meet the children and a limitation is therefore lack of detailed information about the use. This is needed in further research. It is also of great importance to explore the views of the children.

Keywords: Augmentative and alternative communication, Computer access, Pediatrics, Usability.

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Child and Environmental Factors Influencing Selection of Eye Gaze Technology for Trials and Adoption for Young Children: An Interprofessional Pilot Study

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Background: Little research is available about characteristics of preschool candidates for eye gaze technology and environmental influences (parental, staff and agency) contributing to selection of eye gaze technology for trials and adoption. Our goal was to determine factors influencing selection of eye gaze or another method for computer access for preschoolers with disabilities.

Method: During 2015–17, we conducted a field study with a convenience sample of twelve children, ages 3–6, attending special preschools. All children had access to agency-funded or borrowed eye gaze technology for training; trial data of participation and accuracy were collected by speech pathologists. Children participated in trials 30–90 minutes per week. We reviewed children's medical and educational records. Thirty-two service providers and 12 parents were interviewed or surveyed about their knowledge of eye gaze technology and the children's abilities.

Key results: The children's diagnoses included cerebral palsy (10) and rare neuromuscular disorders (2). Other conditions included dysarthria (12), seizure disorders (5), hearing impairment (1), cortical visual impairment (2); nystagmus (1). All had significant postural issues. All were transported in manual wheelchairs most of the time. All had difficulty handling or could not handle objects. Using any means, four children could communicate with familiar partners; the rest were inconsistent or seldom effective with familiar partners. Teams did not use cognitive scores as indicators of potential, but all children could demonstrate preferences and look at a screen.

Parental, staff, AT Team and agency factors were as follows: All parents consented to children's trials, and half had home-based trials. In year one, only 5% of multi-disciplinary staff members reported having formal training in eye gaze technology. In year two, staff with formal training increased to 70% through agency workshops. The staff cited these supports from the AT Team to be helpful in decision making: equipment loans (96% cited), implementation strategies (75%), programming (62%), team meetings (62%), instruction (62%), funding proposals (50%). The agency funded the AT Team and devices; 90% of staff perceived agency as supportive of technology.

Teams recommended the following after each year of implementation:

Year 1 – One child: Acquire insurance-funded eye gaze technology AAC; One child: Acquire insurance-funded touch-activated AAC; Three children: Continue training; Two children: Discontinue eye gaze technology.

Year 2 – Four children: Acquire insurance-funded eye gaze technology AAC; One child: Acquire insurance-funded touch-activated AAC; Three children: Continue training.

Conclusion: Preschool candidates for eye gaze technology have complex conditions impeding occupational performance. Difficulty communicating indicates widespread need for AAC in this group; seating, portability, mounting and transportation require consideration. Difficulty with manual selection of icons

on a device suggests that eye gaze be considered as an access method, but children's skills may advance and allow touch activation eventually. Children's training may extend over a year before recommendations. Some children may reject eye gaze technology. AT Teams cannot assume staff members' knowledge; professional development can increase staff expertise. Valued AT Team support can consist of equipment, strategies, meetings, instruction and funding. Agency funding may be critical to implementation. Parent participation is necessary in decision-making.

Keywords: Eye gaze technology, Preschool, Professional Development, AT Team.

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Eye Gaze Technology's Effect on Participation and Functional Independence

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Background: To actively participate in activities are challenging for children with severe disabilities worldwide. Few assistive technology interventions have the potential to support children in performing a variety of activities in everyday life. Eye gaze controlled computer (EGCC) is today a possible intervention for service providers around the world. Previous research in Sweden showed increase in activities with EGCC after 9 months intervention. To strengthen research more children should be followed in EGCC outcomes. The aim was to investigate the impact from EGCC in daily life on active participation in activities (type, frequency and duration), functional independence, and communicative behavior among pupils with severe disabilities.

Method: A multicenter intervention study with repeated measurements including 18 children (Sweden, USA, Dubai). Results for 8 pupils attending special school will be presented (Sweden $n = 3$, age: 3–7 y; Dubai $n = 3$, age: 17–23 y; USA $n = 2$, age: 5–6 y). All had severe physical disabilities (e.g. Rett syndrome, cerebral palsy, Lesch-Nyhan disease, intellectual disabilities), dependent on assistance and without speech. Intervention consisted of EGCC in daily life (Tobii I12+, I15 or Tobii PCEye Go) and services (Swe: 5–8 occasions; Dubai, USA: every week) during 6 months by an AT team to support implementation in daily contexts. Data were collected four times; before intervention (no EGCC), at 3 and 6 months EGCC intervention, after the end of intervention (no EGCC). Active participation in daily activities were documented with diary protocols (all time points). Key persons rated the impact from technology on functional independence and communicative behavior (at 6 months intervention) using Psychosocial Impact of Assistive Devices Scale (PIADS) and Communication Matrix.

Key results: All pupils performed activities with EGCC at 3 and 6 months intervention; six pupils in school and two both in school and at home. At 6 months the activity repertoire with EGCC ranged from 1–6 activities (Swe: 1,3 or 4 activities, e.g. talk, play, skill training; Dubai: 1,5 or 6 activities, e.g. talk, skill training, story selection; USA: 2 or 4 activities, e.g. talk, play, circle time), compared to no computer activities for seven pupils before intervention and for no one after intervention. Duration ranged from 12–323 minutes per userday (Swe: 12 m, 73 m, 75ąd'm; Dubai: 60 m, 72 m, 73 m; USA: 40 m, 323 m). Activities were performed between 36–100% of days (Swe: 36%, 64%,100%; Dubai: 71%, 71%, 71%; USA: 64%, 71%). Preliminary findings indicate that activities, duration and frequencies with EGCC were similar between pupils with different diagnosis, nationalities and ages. Using EGCC, functional independence (PIADS) showed positive values for all but one child in competence (median 1.21, range -0.08 -2.00), adaptability (median 1.3, range 0.17–2.50) and self-esteem (median 0.8, range 0–1.88). Preliminary results indicate emerging communicative behavior for some children with EGCC compared to without EGCC which will be discussed at the session.

Conclusion: The results for the first eight pupils indicate increase in active participation and functional independence after 6 months EGCC intervention. Slow development in general among children with severe disabilities indicate improvements in daily life from EGCC use. Our future investigations will answer research questions concerning changes in communicative behavior and degree of dependence with and without technology use.

Keywords: Children with disabilities, Intervention, Assistive technology, Self-help devices.

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Facilitating Participation in Routines and Activities for Individuals with Complex Challenges by Use of Eye Gaze Intervention in a Transdisciplinary Special Education Setting

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Background: For students with profound and multiple disabilities, who are eye gaze users, it is challenging to implement their IEPs through use of customized activities and resources in all school routines. This study highlights how eye gaze intervention has been embedded in various routines and activities at Al Noor Center for Persons with Disabilities to ensure participation and learning for individuals with complex communication challenges. Two approaches that constitute the bedrock of the Center's service delivery process viz. trans-disciplinary approach to assessment/intervention and activity and routine-based intervention are described. The aim of this part of the seminar is to describe implementation of eye gaze technology in a transdisciplinary special educational setting for students with severe challenges.
Method: Five eye gaze users participated in the study from Jan 2018 to Sept 2018. Trans-disciplinary intervention, training support to teachers, teaching assistants and therapists in the use of eye gaze technology, routine – based intervention and customization of resources etc. were used to ensure implementation of eye gaze training for each eye gaze user. Student – specific eye gaze equipment was made available through the school day. Thrice weekly individualized skill-specific training in eye gaze was provided. This initiative was guided and led by the Assistive Technology Specialists.
The IEP was implemented through appropriately planned activities ensuring access to eye gaze equipment in every routine. The routines included

- Communication (apps with text/ symbols)
- Academics (e-books, PowerPoint slides)
- Literacy (customized Communicator page-sets with IEP goal-specific grids)
- Music (accessible apps, software Beamz Music, Eye-play Music)
- Leisure (watching YouTube videos of their choice, online radio page-sets, Tic Tac Toe, Makeup page-sets, HelpKidzLearn games)
- ICT (page-sets for making greeting cards, LookToLearn software, SenICT activities)
- Art (creative art software, online Mandala creator, digital painters, pixel drawing)
- Vocational training (designing merchandize), etc.

Assessments such as Communication Matrix, Co pass assessment, Psychosocial Impact of Assistive Devices Scale, Quebec User Evaluation of Satisfaction with Assistive Technology were used to measure the usage and benefits of eye gaze.
Key results: Eye gaze usage within Al Noor's structured service delivery setup has provided opportunities to the students to access all routines, which otherwise would not have been possible. Examples of participation of eye gaze users in activities include in a music band, designing of merchandize for sale, accessing YouTube videos for leisure etc. and in areas such as communication, ICT, art, literacy etc. Learning outcomes were attained in specific skills of duration and frequency of eye gazing. Desire to communicate and eagerness to participate were observed amongst the eye gaze users. Some students displayed fatigue to tasks requiring complex and sustained eye gaze movements. This was addressed through task – breaks to overcome fatigue.
Conclusion: Structured service delivery processes, intensive staff training, access to resources and equipment and providing appropriate opportunities within routines are some of the key factors that have influenced the outcomes of this study. This study illustrates the need for service providers to integrate assistive technology devices and services into the core service delivery process to ensure participation and learning for the intended beneficiaries.

Keywords: eye gaze, trans-disciplinary intervention, routine-based intervention.

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Combining P300-based Brain Computer Interface with an Eye-tracking System to Improve Communication Efficacy for People with Ocular Motor Impairment

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Background: Brain computer interface (BCI) systems allow people with severe motor disabilities interact with the environment representing an alternative channel to access assistive technologies for communication disorders. When eyes movement are preserved but user experiences severe motor impairment, high technology aids as eye-trackers are efficient and effective solutions. However, eye-trackers performances decrease in case of oculomotor impairments such as nystagmus, gaze paralysis. On the contrary, P300-based BCIs do not rely on eye movements but on the subject ability to attend relevant stimuli. In this work we propose a hybrid algorithm, based on both EEG data and eye-gaze position, with the aim of improving efficiency and effectivness of communication aids for people with oculomotor impairments.
Method used: The hybrid BCI is based on an iterative algorithm, originally proposed by Kalika et al. 2017 that computes the probability of each item to be target as the combination of EEG and eye gaze position *a priori* probabilities. When total probability reaches a specific threshold the algorithm provides a classification result, otherwise another iteration occurs. We assessed EEG score values using a stepwise linear discriminant analysis (SWLDA) and *a priori* EEG probability was computed by linear interpolation of scores on the distributions of target and non-target stimuli. To estimate *a priori* eye-gaze probability, we assumed equal and Gaussian distributions for each item, Gaussian mean was estimated by a least square linear regression (LSLR) and covariance as the maximum of the vertical and horizontal gaze coordinates variance. We introduced constraints on the classification threshold, introducing a threshold value on the EEG scores and considering a dwelling time for the eye-gaze position. We preliminary validated offline the proposed algorithm on the data recorded from 10 healthy participants. Participants were required to carry out a P300 Speller session. Scalp potentials were collected at 256 Hz with 16 EEG active channels. Eye-gaze positions were recorded using a Tobii 4C eyetracker. The P3-speller interface (5×6 matrix of alphabetic items randomly flashing) was provided by BCI2000. We collected 8 runs of 5 characters each. In order to assess algorithm efficacy we computed the written symbol rate (WSR-REF) and exploited different variance values for eye-gaze data.
Key results: Because of low values of eye-gaze variance (0.001) no statistical differences were identified in terms of WSR for the hybrid algorithm with respect to the solely eye-tracker ($t = -0.19$, $p = 0.84$). If eye-gaze variance increases (0.1) the hybrid algorithm showed higher WSR values with respect to both eye-tracker ($t = 6.57$, $p < 0.001$) and EEG ($t = 3.72$, $p < 0.01$). This confirms that with eye movements impairments, the combination of eye-tracker data and EEG data allows for better performance.
Conclusion: Hybrid control could represent a solution to increase communication efficacy for people with ocular motor impairments who experience a decrease in performance with eye-trackers. As expected, with healthy subjects the classification algorithm is mainly driven by eye-gaze data, but offline simulations showed that EEG data improves classification performance when the reliability of eye-gaze data decreases. We will evaluate the algorithm with potential end users to further verify our hypothesis.
Keywords: Brain Computer Interface, Eye-tracker, assistive technology.
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Special Thematic Session 6
Employing MOOCs and OERs in Teaching Digital Accessibility

In 2016, the European MOOC Accessibility Partnership (MOOCAP) launched the first European MOOC on digital accessibility, on the FutureLearn platform. Since then, other MOOCs on specific subtopics of digital accessibility have been released, by MOOCAP partners and by other parties. In Europe, there is an urgent need for education and training of students and professionals studying and working in areas involving digital media. MOOCs and Open Educational Resources (OERs), optionally integrated with presence time ("blended learning"), are deemed to be an appropriate means to satisfy this need. Initially started by MOOCAP, there is a growing European community with a joint interest in harnessing MOOCs and OERs in teaching digital accessibility for a wide audience, including students at universities and professionals at work. It is imperative to join forces, learn from each other's experiences and share best practices and OERs, since the field of digital accessibility is so wide, and experts are scarce and geographically distributed. The BEYOND-MOOCAP network will host this Spe-

cial Thematic Session to facilitate an exchange of best practices and a platform for sharing OERs to reuse and for translation into local languages. All interested persons and parties are welcome to join us and contribute to this session.
Chair: *Gottfried Zimmermann*

Designing a MOOC for "Training the Trainers"
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Background: EU Directive 2016/2102, voted in October 2016, requires that new public sector websites in the EU need to conform European standard EN 301 549 by 23 September 2019. Other public sector websites and public sector apps will eventually also need to comply. The European Accessibility Act, approved by the European Parliament on 13 March 2019, will greatly expand the range of products and services that need to be accessible, including computers, e-commerce websites and mobile apps. This creates a greater need for training resources and courses for content authors and developers, among others. The MOOCAP project (2014–2017), co-ordinated by Stuttgart Media University, created 10 online courses, including four MOOCs, on digital accessibility. The resources from these courses met WCAG 2.0 level AA and were all made available as open educational resources under the terms of the Creative Commons (CC-BY 4.0) licence.
Method: The above-mentioned courses and resources are in English and many EU member states will need training resources and courses in other languages. Informal discussions with representatives of German municipalities have taught us that a course on digital accessibility should use materials in German. In Germany, Stuttgart Media University is creating a MOOC in German that is aimed at civil servants who will be in charge of leading accessibility projects and/or training developers and content authors who will be involved in making websites and apps compliant with European accessibility regulations. The target audience also includes designers and developers of digital systems in general. The course content will meet WCAG 2.1 level AA. The course will combine three face-to-face meetings, and online course modules that are spread over four months. Each online module will contain required reading and practical tasks that will be discussed in regular online meetings (typically on a weekly basis). The course will cover accessibility basics, laws and regulations, multimedia, web accessibility (WCAG 2.1), office documents (Word, PowerPoint and PDF) and inclusive design processes.
Key results: The course contents is being developed; the course itself is scheduled to start in October 2019.
Conclusion: Since the course has not started yet, no conclusions can be drawn at this time.
Keywords: accessibility, training, resources.
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Using MOOCAP Open Educational Resources to support Universal Design and Accessibility initiatives in Computer Science programmes in Ireland's first Technological University
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Background: The recently completed Massive Open Online Course for Accessibility Partnership project (MOOCAP), funded by the ERASMUS+ Key Action 2 (KA2) grant program of the European Union, had the twin aims of establishing a strategic partnership around the promotion of Universal Design and Accessibility for ICT professionals and of developing a suite of Open Educational Resources(OERS) in this domain. This study considers how the MOOCAP OERS were used in two different situations in undergraduate computer science programmes in the Technological University of Dublin which both have digital accessibility as a common learning goal. This reflects the reported need to promote accessibility considerations amongst ICT professionals.
Method: This research involves two case studies with analysis using the Johns model of reflection. Some surveys have also provided reflective feedback. The first case study examines the role of OERs to modernize accessibility topics in a Universal Design and Assistive ICT module and the second looks at how the OERS are a valuable resource in developing a training program in the preparatory stage of a team project module. The team project uses an Agile Co-Design model with partners with Intellectual Disability. Fifteen students took part in the first case study. Twenty four students took part in the second case study. The results of these case studies will be considered in comparison to already reported international use of the MOOCAP content.

Key results: Prior to engaging with these modules, there was little knowledge of accessibility among the students. Both modules increased awareness of the role of the user in computer science. The Co-Design process was especially significant in this regard with student participants reflecting that it had changed their perception of development. Requirements were typically given to them in previous assignments. Now they have to find out what the users wanted. The OERS were an interesting and helpful resource in meeting the learning outcomes of the module. The team projects needed strong preparation and the OERS helped in achieving this. Feedback was also given that more examples of best accessible applications should augment the OERs used.
Conclusion: It is essential to promote accessibility knowledge amongst the ICT developers of tomorrow. The role of the user in application development is central to this. The MOOCAP OERS are a valuable resource in this regard. They can help achieve these outcomes in many different ways. A repository of best accessible applications would be a useful addition.
Keywords: Open educational Resources, MOOCs, Digital Accessibility, ICT Professionals.
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Harnessing MOOCs and OERs in teaching digital accessibility – experiences with a flipped classroom approach

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Background: The past few years have seen a pressing need for students and professionals in information technology (IT) to learn digital accessibility. As a consequence, an increasing number of universities have started to include digital accessibility in their IT curricula, alongside some open educational resources (OERs) and Massive Open Online Courses (MOOCs). Researches have also been carried out on pedagogies and methods in teaching digital accessibility. A flipped classroom is a pedagogical approach that promotes learner-centered instruction and replaces the traditional transmissive lecture with active in-class tasks and pre-/post-class work. In this paper we share our experiences on teaching digital accessibility using the flipped classroom approach and OERs and MOOCs created in the EU erasmus+ funded "MOOCs for Accessibility Partnership (MOOCAP)" project.
Method: The study was carried out in 3 runs of the same course from 2016 and 2018. Each run lasted for 6 weeks where the first 5 weeks were dedicated to course content and the last week were used for course summary and exam. The 5-week's content was correspondent to the 5 weeks in the introductory MOOC for digital accessibility created in the MOOCAP project. In the flipped classroom approach, we have used the OERs (in 2016) and the introductory MOOC (in 2017 and 2018 ran in parallel with the course) as the pre-/post-class work. To prepare for the classroom activities students were asked to read the text and watch the videos in the OERs and the MOOC. For classroom activities, we focused on collaborative knowledge building where students were first asked to share with each other what they have learned from the reading, and then discuss important issues related to digital accessibility. For example, what criteria can one use to select users in a user testing of web accessibility? What are the challenges in developing an accessible web form? What are the accessibility barriers can an ATM have on diverse user groups? In total, 70 students participated in the 3 runs of the course. At the end of each run an online questionnaire was distributed to gather feedback. In the questionnaire there were also fields where students could write their opinions in free text.
Key results: The feedbacks from students were in general positive. Most of the participants reported that they have enjoyed the flipped classroom approach and learning materials in OERs and the MOOC. They also thought that the materials were very useful. However, a few students reported that the approach did not fit well with their preferred learning method. They preferred to be taught rather than self-study. When some students did not prepare before class, it was difficult to organize classroom activities.
Conclusion: Our experience shows that using a flipped classroom approach to harness OERs and MOOCs in teaching digital accessibility is a promising approach. However, it is also important to take into consideration the diverse preferences and abilities of students. Further research could replicate the study, gather more evidence and provide recommendations in using OERs and MOOCs in flipped classroom for teaching digital accessibility.
Keywords: digital accessibility, MOOC, OER, flipped classroom, education.
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Exploring the impact of the Digital Accessibility MOOC

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Background: Since 2016, the Erasmus+ European project "MOOCs for Accessibility Partnership" (MOOCAP) has hosted their introductory five-week digital accessibility massive open online course (MOOC) four times. The eight partner universities provided multimedia resources and links to a wide range of topics about assistive technologies and accessible design in ICT. The MOOC aimed to help participating learners understand how those with sensory, physical and cognitive impairments may be disabled by barriers encountered when using digital technologies. By using the FutureLearn platform there were plenty of chances to discuss content, make comments as well as reflect on what had been learnt. These interactions provided the partnership with a greater understanding about the impact the MOOC had on some learners and this paper aims to explore six case studies that illustrate particular outcomes in the workplace.
Method: By examining the data collected from the FutureLearn statistics for the four Digital Accessibility MOOCs from October 2016–2018 it was found that 11186 learners signed up. 6670 engaged with the courses in one way or another and 1127 completed the courses with 1667 interacting by posting comments about the subjects discussed. On average learners commented around 13 times over the course of each MOOC. This amount of interaction was shown to be above the normal range for this type of online learning. The authors asked certain participants, who had a documented web presence, if they could explore their interactions further. The resulting six case studies were also chosen from participants with very different areas of expertise and how they shared their experiences during their interactions online.
Key results: As the case studies were collated, it became clear that the participants were not only active learners but also engaged with the majority of the content, links and formative assessments. They appeared to have a high number of comments that were 'liked' by other participants, and discussed topics with the tutors or mentors. Most interestingly when analyzing their reflective comments at the end of the first week, it appeared all six had professed that they intended to take what they were learning into their workplace.
Conclusion: The learners came from across the world and were based in research and educational institutes, designing user experiences for the elderly or tutoring dyslexic adults, working as a digital learning consultant or leading on accessibility in large well-known companies. Despite the different employment settings, all acknowledged that the course had provided them with the confidence to expand on their work in this area. Moreover, they said it had allowed them to provide support to others on the subject of digital accessibility and in most cases, this was evident in their web presence after the MOOCs took place.
Keywords: Digital Accessibility, MOOCs, Disability, Case Studies, Learners.
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Special Thematic Session 7
AI and Inclusion – Exploring the issues as well as the successes

Artificial Intelligence and Inclusion' is a subject that has been debated in terms of ethics and a lack of big data for machine learning when thinking about inclusive design for those with disabilities. The challenges are to overcome these difficulties and to develop technologies to remove the many different barriers to access. Those working in the world of assistive technologies, and digital accessibility are innovating and exploring this field in participation with those who have disabilities. This special theme aims to explore some of the innovations that are appearing and to discuss the issues that have been arising as well as the successes.
Chair: *E.A. Draffan*

AI and Inclusion: A Roadmap for Research and Development

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Background: Artificial Intelligence (AI) was a term coined in the 1950s based on the work of Alan Turing and other machine-learning experts. The term tends to cover the use of data collections, algorithms and models that can augment or assist humans in their decisions and tasks, but there is a deepening awareness that not all data collections are inclusive or algorithms transparent. Ethical issues arise where this occurs and inclusion depends a lack of bias and fairness within the sys-

tems. This abstract presents a roadmap for digital accessibility research and development using AI to support those with disabilities with examples where strategies can help prevent barriers to inclusion.
Method: A gap analysis has been undertaken to investigate where issues might be arising for those who are recognized as having 'protected' characteristics', focusing on those with disabilities. The process included reviews of EU, government, academic and commercial reports, papers. The review used five AI driven search engines, combining the terms artificial intelligence, inclusion, accessibility and disability. An online repository of the findings was developed and as the gaps appeared more in depth investigations undertaken, meeting experts in the subject to evaluate how examples of innovative developments in particular areas, could remove barriers to enhance digital accessibility and inclusion.
Key results: Around 1,782 academic papers were found using the aforementioned terms. Much has already been written about the ethical issues arising from bias and the exclusion of data relating to vulnerable groups within society so papers with 'ethics' in the title were left out of the review. At the time, only 50 papers were considered appropriate with government and disability organization reports tending to highlight the issues arising, rather than offering solutions. The reports 'that included 'disability' appeared to consider it as a homogeneous concept that could lead one to believe that one solution would fit all if it was provided. AI and inclusion appeared to be poorly defined, when thinking about disability, with many papers considering medical issues and not accessibility or design for all. Authors described using AI to support assessment, diagnosis and support for diseases and health conditions, smart living, homes and cities. Some were about assistive apps to support specific disabilities, but rarely about equity of access. It still seems that those with disabilities are expected to use additional AT without a guarantee of accessibility to the digital and built environment.
Conclusion: Successful inclusion of all vulnerable groups within the AI research and development arena remains patchy, in particular when considering strategies for access to aid those benefiting from a wide range of technologies. However, when exploring both policy and machine learning applications catering for the heterogeneity in disability (where barriers are removed), there are a variety of strategies that enhance digital accessibility. These may include personalization, localization, risk assessments, anomaly detection, and prediction or recommendation systems. Outcomes can be biased against particular needs, but if there is an awareness of these issues and algorithms are designed to cater for inclusion, enhanced digital accessibility can be achieved.
Keywords: Artificial Intelligence, Inclusion, Accessibility, Disability, Design for all.
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The four idols of AI for health and wellbeing
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Background: In the last decade or so, increased computer processing and storage capabilities, along with the availability of big data sets, have stimulated the development of more elaborate inductive machine learning algorithms and architectures. These have delivered impressive results in tasks such as natural language processing and image recognition, so much so that in contemporary usage AI has become practically synonymous with inductive machine learning and, more specifically, with deep learning.
Moreover, these results have, quite naturally, raised expectations that, with just the right amount of effort, these results will be repeated across a range of domains, automating all sorts of mundane (and not so mundane) tasks. The expectations – and accompanying hype – are such that AI now consistently appears in policy documents as a key driver of innovative services and products, of productivity gains, and of wealth and job creation across all sectors of developed economies. The health and social care sector, with its escalating needs and straitened budgets, seems particularly susceptible to the claims of proponents of this new AI. However, the degree of faith placed in AI to deliver the imagined gains is not yet borne out by evidence. There are a number of reasons to believe that the gains, while by no means negligible, will be more limited and will be more difficult and take longer to achieve and disseminate into everyday care practice and assistive technology.
Method: This discussion paper draws on the authors' experience of working with and around AI and health and wellbeing applications. Its theoretical inspiration is drawn from the work of the British philosopher Francis Bacon, one of the progenitors of modern inductive method, who in his *Novum Organum* (1620) identified

four 'idols of the mind', that is, types of common fallacies or biases that divert reasoning from the acquisition of 'true' inductive knowledge.

Key results: We propose "the four idols of AI for health and wellbeing", which apply equally to assistive technology; these are:

- *The idols of the tribe*, or fallacies that emerge from the conviction that there is, of necessity, 'true' knowledge inherent in data;
- *The idols of the cave*, or mistakes that derive from our ignorance, wilful or otherwise, of the limitations of the methods and means at our disposal;
- *The idols of the marketplace*, or the constraints which human commerce places on our endeavours;
- *The idols of the theatre*, or the failings that arise from incorrect, ill-considered or improper use of AI.

As we show, consideration of these idols allows the adoption of strategies and practices to mitigate their effects.

Conclusion: A contribution is made to a critical appraisal of the use of inductive machine learning, particularly deep learning, in care contexts. When considering the application of machine learning for assistive technology an awareness of the pitfalls should help to allocate scant resources to those tasks most likely to benefit end users.

Keywords: Artificial Intelligence, data, machine learning.

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AI Bias in Gender Recognition of Face Images: Study on the Impact of the IBM AI Fairness 360 Toolkit

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Background: Artificial Intelligence (AI) has great potentials, but also comes with risks. In particular, the "AI bias" has been described as a phenomenon that can marginalize persons with disabilities or classify as outliers. This would potentially exclude those persons from fair access to important services such as health insurance and loan programs, or at least significantly hamper them. The IBM Fairness 360 Open Source Toolkit (AIF360) addresses this problem. Its goal is to "examine, report and mitigate discrimination and bias in machine learning models". It was developed by IBM and announced in September 2018. The toolkit contains 10 algorithms to mitigate bias in AI systems. One of them is "reweighing" which is suitable for image recognition. So far, there has been little research on the impact of AIF360 regarding its ability on mitigating AI bias, and its applicability on various problem domains that are typical for the application of AI algorithms.

Method: We conducted a small study on the impact of AIF360's reweighing algorithm on the accuracy of gender recognition for face images of persons with and without Down Syndrome (DS). We used the gender recognition algorithm and a training set of 20.000 images from the UTKFace dataset which is included in the AIF360 package. These images were tagged with the gender of the person, but not with any information on DS. Also, we collected 30 images from public domain sources on which persons with DS were displayed; and 30 images from the same sources with persons without DS. The study consisted of two parts which differed in the set of training images. In part (1), we trained the system with random 16.000 images from UTKFace. In part (2), we trained the system with random 15.984 images from UTKFace plus 16 images of persons with DS (from public domain sources) – a proportion of 0,1% which is roughly the proportion of persons with DS in the German population. In both parts, we tested with images from public domain sources: 30 persons without DS and 30 persons with DS, in two modes: default algorithm and reweighing algorithm.

Key results: We found no evidence for a manifestation of the AI bias under this configuration. Gender recognition accuracy with the default algorithm was a low 70% for persons without DS and 80% for persons with DS in part (1); and 70% for persons without DS and 73,3% for persons with DS in part (2). However, when using the reweighing algorithm in part (2), there was a slight improvement from 73,3% to 83,3% accuracy. However, the sample size was too small to claim a representative assessment for this algorithm.

Conclusion: The AIF360 toolkit is a candidate instrument for the mitigation of AI bias. According to our study, the reweighing algorithm has the potential to improve the gender classification accuracy, but research with a larger sample needs to be conducted to confirm this.

Keywords: AI bias, Down syndrome, reweighing algorithm, gender recognition

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Machine Learning: Design by Exclusion or Exclusion by Design?

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Background: Many applications, from image recognition to providing credit ratings for loan applicants use Artificial Intelligence (AI) and Machine Learning (ML). They have become major technologies in everyday life. However, commentators such as the Obama White House and the World Economic Forum have noted the potential of these technologies to exclude and discriminate. This discrimination typically starts with datasets that exclude or underrepresent particular groups of people, including people with disabilities. This exclusion propagates through the Machine Learning algorithms, used in these technologies. In other words, these algorithms have developed from a design process tainted by exclusion. How does this exclusion occur in the datasets? Is it deliberate, i.e. exclusion by design or are there other reasons?
Method: This study involves a comparative analysis of four case studies from the domains of education, speech recognition, fall prediction, and credit card risk assessment. These all have important resonance for people with disabilities. Comparison is across the dimensions of:

- origin and characteristics of the dataset,
- whether exclusion is manifest or not in the dataset,
- if this exclusion is deliberate,
- what preprocessing occurs on the data set and
- implications for people with disability.

Key results: The key finding is that there is exclusion of certain groups of people in datasets used for machine learning applications. This exclusion can have serious consequences for the people who are discriminated. Education and job opportunities can be lost. A creditor may refuse a loan because the applicant is wrongly classified.
How has this exclusion happened? It may be down to ignorance. It may have been deliberate but motivated by good intentions with respect to privacy or safety or ethical concerns. It may simply be that this dataset is the only one available regardless of its flaws. However all is not lost and there may be remedial processes, especially in the pre-processing phase, which can provide some redress. Oversampling and under-sampling are of particular importance
Conclusion: It is especially important to develop inclusive datasets across many applications for underrepresented groups in machine learning. Inclusive dataset protocols and techniques, which respect ethics, privacy and safety, need to be developed. The efficacy of inclusive pre-processing techniques such as oversampling needs exploration.
Keywords: Machine Learning, Artificial Intelligence, Exclusion, Datasets, Disability.
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Accessibility and Stigma: Designing for Users with Invisible Disabilities

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Background: While chronic pain due to overuse (e.g., Repetitive Strain Injury, some types of back pain) is often discussed in the ergonomics and accessibility literature, there are many invisible conditions such as fibromyalgia that are characterised by complex, chronic patterns of pain and fatigue. People living with those conditions often find that the number of tasks they can complete in a day is severely limited. This can be a significant barrier to fulfilling even basic needs such as self-care. At the same time, people with chronic pain are often stigmatized as "lazy", because there are often no visible signs or clear causes of their condition. Physiologically, pain affects mobility and dexterity, and un-ergonomic technology can create or exacerbate chronic pain. In this paper, we examine the extent to which these issues are acknowledged and discussed in the literature on providing healthcare or assistive technology for people who live with chronic pain.
Method: Searches covered the ACM digital library (ACM publications) and PubMed. The keyword for the ACM digital library was "chronic pain". PubMed was searched for "chronic pain" and "technology use"/"accessibility"/"usability". In addition, five key journals in the field, Technology and Disability, Journal of Enabling Technologies, Disability and Rehabilitation Technology, Assistive Technology, and the Journal of Rehabilitation and Assistive Technologies, were searched for the term "chronic pain". Chronic pain was used as the umbrella term for relevant conditions because it is a defining feature and likely to occur in the abstract, key words, or full text.
Key results: The papers retrieved are mostly concerned with eHealth solutions for chronic pain man-

agement and self-management. There is almost no consideration of ergonomic aspects. Within the health field, interventions are mostly evaluated for effectiveness and acceptability, some for usability. When accessibility issues were evaluated, the focus was on accessibility for visually impaired users, not on impairments of mobility and dexterity. There was also very little in-depth consideration of the work and effort required to integrate technology into the daily life of somebody with chronic pain. A few papers highlighted that people with chronic pain were particularly affected by the digital divide.

Conclusion: Chronic pain affects mobility, dexterity, and people's ability to do the work required to use and look after their technology. These aspects are mostly neglected in the HCI, eHealth, and assistive technology literature on designing for people with chronic pain. We need to determine the relevant accessibility issues before we can begin to leverage AI meaningfully to address them.

Keywords: chronic pain, accessibility, stigma, inclusion

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AI and AAC: Linking Open Symbol Sets – A Global Approach

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Background: Artificial Intelligence depends on big data sets to provide successful outputs from algorithmic modelling. However, in the world of augmentative and alternative forms of communication (AAC), where individuals with complex communication needs may use symbols, data is scarce. This means that non-speaking symbol users have restricted choices, depending on symbol to text when communicating online with little text to symbol translation. The conversions are fraught with complications due to the different types of linguistic concepts, imagery and languages. At present, there is limited harmonization or standardization of symbol sets, so users find it hard to access suitable localized imagery to fit their present systems, unless manual modifications are made. This paper shows how symbol sets can be linked with multilingual options and how plans to use image recognition and more detailed metadata could improve outcomes

Method: The last ten years has seen studies examining the possible harmonization of different AAC symbol sets. These offered users the chance to communicate with their preferred symbols in phrases and sentences that were transcribed into text and then converted into another set of symbols from a different symbol set and into another language. The conversions used a concept coding framework with symbol sets such as Blisssymbolics and ARASAAC using European languages. This idea has been extended with the use of ConceptNet (a semantic network) and additional metadata with a wider range of languages to allow for the linking of an infinite number of symbol sets. It is proposed that the use of machine learning and image recognition could further enhance the process with a diverse range of symbols that have free to use licenses and are appropriate for AAC users across the world. This would result in ease of access to more pictographic based communication that could be personalized, localized and become increasingly culturally suitable for globalization.

Key results: So far it has been possible to automatically link five multilingual and multicultural open AAC symbol sets, providing a repository that can be searched or filtered using categories such as language, concept, label, category and parts of speech. Languages vary from Hindi to Spanish, Marathi to Arabic with the symbol sets ranging from those suitable for adults to Blissymbolics with its own grammar. All can be used with communication chart builders using an open board format (obf) for digital, online and paper based communication systems.

Conclusion: There may be challenges ahead for those wishing to explore open symbol set development to provide users with choices adaptable for personalized communication. However, a global symbols' model offers avenues into literacy and understanding of symbol to text based content. The addition of symbols for online informational content has already been considered by the Web Content Accessibility Guideline cognitive and learning disabilities task force and Easy to Read EU project teams. Nevertheless, without harmonization it will remain hard for AAC users to express their ideas, share thoughts and comprehend content across our digitally networked world.

Keywords: Artificial Intelligence, Augmentative and Alternative Communication, Symbols, Multilingual, ConceptNet.

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IoT-Based Observation Technology for Assessment of Motor and Cognitive Conditions in Children with Severe Multiple Disabilities

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Background: Medical advancement has increased the survival rates of newly born babies with multiple disabilities, which has increased the number of non-speaking children with limited responses during interactions. In order to provide good support to and interaction with them, it is urgently needed to achieve an objective means that helps to assess their motor and cognitive conditions. In this study, IoT-based observation technology was developed, which helps to record and evaluate the responses of those children while various stimuli are presented. The usefulness of the system in assessing their motor and cognitive conditions was investigated.

Method: The following two applications were developed, which support the observation of the responses of children with severe multiple disabilities. The first app, TEAK (Team Entry Assessment Kit), was designed to navigate the user, e.g., the children's parents and teachers, with the instructions of how the stimuli are presented during the observation. The app asks the user about the child's response toward the stimuli and choose a number from a five-level scale that associates with their body movement. The observed data are stored on the server and can be graphically presented with potentially related information, such as environmental information, which is collected over the Internet. The second app, OAK (Observation and Access with Kinect), was developed in our former study and visualizes the location and amount of the body motion using the camera of the smartphone/tablet. This app creates images in a heat map format with a six-color scale based on the frequency of the brightness change, which corresponds to the motion of the user, in each pixel of the captured video. New observation function including the automatic presentation of visual, auditory, and tactile stimuli using IoT technology was additionally implemented to OAK. There were 33 participants, 10 parents and 23 special education teachers, in the experiment. Each participant observed a couple of children with severe multiple disabilities using one of the apps, and there were 27 children in total. The participants were interviewed after the observations.

Key results: TEAK successfully navigated the participants to conduct controlled observation and helped to find previously unnoticed motor or cognitive abilities of several children. Meanwhile, many of the participants requested a simpler technology than the app. This led to a new feature that enables the user to save the observed information via voice using smart speakers (Amazon Echo) or by activating IoT devices (AWS IoT Button). OAK observation also successfully helped to conduct more precise assessment. For example, a non-speaking child's slow voluntary response toward auditory stimulus was identified.

Conclusion: In this study, two IoT-based observation apps were developed, which records and helps to evaluate the responses of children with severe multiple disabilities toward various stimuli presented. The experiments showed that the apps helped to find previously unnoticed responses and gave more precise information of motor and cognitive conditions of the children. The details of each case and how IoT-based technology can contribute to have more effective interactions with them will be discussed at the presentation.

Keywords: IoT, Assessment, Severe Multiple Disabilities, OAK, TEAK.

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IoT-Based Continuous Lifestyle Monitoring: The NOAH Concept

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Background: Among most demanding societal challenges, population ageing is stressing the need for "active" ageing, preserving chances of independent living in the older age. Rescue services, fall detection, telemedicine already proved their effectiveness in increasing self-reliance of older adults living alone: Internet of Things (IoT) technology, providing distributed home intelligence at low costs and low intrusiveness, may open further opportunities. Conventionally, remote clinical parameter monitoring is performed by using specific medical devices; this, however, require schedule compliance and skill and, in the longer perspective, outcomes can be jeopardized by carelessness and boredom. Complementarily, information about meaningful changes in health and wellbeing can be obtained by indirect observation. Many medical conditions, in fact, manifest themselves with behavioral symptoms (e.g., unusual sleeping patterns, or reduced physical activity) which, in turn, can be inferred by tracking home activity, without any action required to the user. This relieves the user from demanding measurement schedules and is suitable for users having no actual skill (e.g., cognitively impaired persons). Inherent challenges come from the need of recognizing relevant features within a continuous flow of unspecific data. User-specific knowledge is needed, which in turn calls for adaptive approaches.
Method: In the NOAH project (funded in the framework of AAL-JP programme), continuous monitoring is introduced, based on a new generation of IoT daily life activity sensors that detect routines as bed patterns, toilet usage, room presence, and others. Such devices exploit the Wi-Fi communication protocol, connecting directly to the Internet, with no need of home hubs. This makes the approach extremely flexible and simple to deal with, supporting personalization and self-management. A suite of cloud-based analytics tools (ranging from statistical analysis to deep-learning techniques) is available to extract meaningful information, such as behavioral trends (either slow or abrupt) and anomalies. Unsupervised analytics is based on the acquisition of user-specific behavioral profile, so that relative changes are assessed, with respect to learned habits. Multivariate clustering techniques are exploited to work out multi-modal profiles, in which multiple customary activity patterns can be accounted for (e.g., related to the weekday, climate or mood). Deviations from such patterns trigger communication with the end-user or his caregiver, by means of simple smartphone apps.
Key results: The NOAH system is being deployed at several users' homes (up to 60 at the end of recruitment phase), in three European countries (Italy, Romania, Belgium). A co-creation process, involving end-users and stakeholders, has been exploited to devise main system features. A large dataset is being collected, onto which the analytics engine continuously performs trend and anomaly detection. Through periodic evaluation (involving questionnaires), effectiveness of the approach, as perceived by caregivers, will be assessed.
Conclusion: The NOAH system aims at continuous monitoring of daily living patterns, based on distributed sensing through innovative WiFi-based devices. Cloud-based analysis tools, based on machine-learning techniques, are exploited to sift through raw data, providing caregivers with meaningful health-related insights. The approach is being field-validated to evaluate its impact in fostering better knowledge, and thus better care.
Keywords: Internet of Things (IoT), Behavioral Analysis, Active and Healthy Ageing (AAL), Sensor Networks.
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Field-based innovation methodology and its implementation on development of an information support robot system for the elderly

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Background: Assistive products with cutting-edge technologies are expected for promoting autonomy and independence of persons with disabilities. In order to improve these developments, conventional design methodologies; e.g. human centered design, design thinking and system thinking; are useful. However, specific development methodologies are sometimes needed especially for non-professionals on assistive product space who have high potential and many technological knowledges. Inoue et.al. proposed field-based development method for assistive products with the 6 steps[1)]. This paper describes establishment of a field-based innovation methodology, which is expanded beyond the field-based development method. Then, development of an information support robot system is introduced as an example of an implementation.

Method: Based on the AT development flamework, field-based AT development method[1)] and non-functional requirement perspective, 7 principles was established as a part of the field-based innovation methodology. Then, development project of information support robot for older people with cognitive decline was conducted, according to this methodology.

Key results: Here shows the 7 principles that was established in this study as follows,

1. Set specific target user groups and clarify body function and level of impairment.
2. Collect users' information about daily life and set the use field and stakeholders.
3. Promote user and stakeholder participation into the innovation process.
4. Select suitable human interface technologies based on the users' body function.
5. Measurement of body functions at the real field is recommended for it. In addition, take into account two non-functional requirement as follows,
   a) Modularization and parameter changing function in order to fit to each user.
   b) Prevention against side effects.
6. Fix the AT's concept after clarifying the settings of their use. In addition, take into account two non-functional requirement as follows
   a) Governmental provision system, insurance and other reimbursement.
   b) Market size. Many of ATs are estimated small market.
7. Modify the AT's concept according to the result of the field test using the prototype. Also, develop fitting methods and service systems related to the ATs from the result and knowledge from the field tests.

Based on the data aggregation of the older people's characteristics in the life fields, the robot's functions were identified; e.g. suitable frequency and speed of robot's speech, suitable information transfer method against the cognitive decline, On the other hand, the concept of the robot system was established from the results of group interviews with 124 older people and 40 care professionals and workshop with 2 families and their stakeholders. The fixed concept of the robot system was to indicate important information within daily life e.g. date, day, schedule, through the conversation between users and the robot. Also, service model for the robot system was established. The results of the field tests for one month with 6 older people living in the olders' apartments showed effectiveness on the medication adherence, consolidation of their life rhythm.

Conclusion: This study showed the field-based innovation methodology, and the development of the information support robot system as an example. It was effective on the establishment of useful concept with complicated users, stakeholders and use field.

Acknowledgement: This research was supported by Strategic Promotion of Innovative Research and Development Program of Japan Science and Technology Agency.

Keywords: AT innovation, Robot system, Cognitive decline, Older people.

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Patients experiences with commercially available activity trackers embedded in physiotherapy treatment: A qualitative study

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Background: Activity trackers show potential for use in health care settings, for example in patients with a chronic disease. Guidelines for physiotherapists recommend measuring the physical activity of patients with a chronic disease. The most frequent used measurement tools are questionnaires and diaries, but they have a limited reliability and validity. Activity trackers can overcome these limitations since they provide an objective measurement and record data real-time. Moreover, activity trackers can increase self-management of the patient and eventually save time and money. However, to implement activity trackers in a healthcare process, like physiotherapy, insight into the feasibility from the patient's perspective is needed. Therefore, the goal of this study was to collect experiences of patients with a chronic disease with commercially available activity trackers during physiotherapy treatment and daily life.

Method: In a qualitative study, 29 patients with a chronic disease (COPD, diabetes mellitus, chronic pain, cancer or osteoarthritis) who were receiving physiotherapy used an activity tracker at least two weeks. The following eight activity trackers were selected: Activ8, Digi-Walker CW-700, Fitbit Flex, LumoBack, Moves, Fitbit One, UP24, and the Walking Style X. The participating physiotherapists received training for the possibilities of the activity trackers, and were free to use the activity tracker in any way they thought was best suited for treatment. Experiences were collected using semi-structured interviews and focus group interviews. A framework was developed that incorporated the most important concepts from the experiences of patients by means of a framework analysis. This framework was used to analyse the data from the interviews.
Key results: Participants were between 22 and 78 years old, and 41% of the participants were insufficiently active. The developed framework included seven categories: purchase, instruction, characteristics, correct functioning, sharing data, privacy, use, and, interest in feedback. Each category had several subcategories. All categories were consistent with the literature used, two new sub-categories were added and four subcategories were removed. The activity trackers motivated patients to increase their physical activity levels and to reach their daily goals. However, participants experienced certain barriers such as high standards goals set by the tracker (10.000 steps) and complexity of the tracker. The complexity decreased their motivation to use the tracker. Participants also missed clear instruction from their physiotherapist about the use and goal of the tracker. Most of the participants did not discuss their data with their physiotherapists, because they placed higher value on the treatment delivered by the physiotherapist. However, participants could see the potential value of using an tracker during their physiotherapy session.
Conclusion: The developed framework gives insight into all important concepts from the experiences with activity trackers for patients with a chronic disease and can be used in further research and practice. In general, patients with a chronic disease were positive regarding activity trackers. However, activity trackers should be adapted to the needs and skills of people with a chronic disease. When using activity trackers, physiotherapists should pay more attention to embedding the tracker in their treatment. Full article can be found: https://www.tandfonline.com/doi/full/10.1080/09638288.2019.1590470?scroll=top&needAccess=true.

Keywords: Activity Tracker, Chronic disease, Physiotherapy, Patient Perspective, Physical activity.
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Smartphone Apps to Support the Self-Management of Hypertension: Identification of the Most Suitable Apps

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Background: Hypertension is a common chronic disease in adults that requires effective patients' self-management. Smartphone apps provide considerable potential to play a key role in self-management, evident in the huge number of apps that have become available over the past few years. However, the increasing number of different blood pressure (BP) apps available on the market creates the urgent need for physicians and patients to be made aware of their effectiveness, and the levels of security and privacy that they offer. This will help to identify apps that are useful and safe.
Method: Two studies were conducted to evaluate apps for supporting the self-management of hypertension. Firstly, a systematic review was conducted, including articles from the years 2008 to 2017 that investigated and assessed functionalities of hypertension self-management apps and their effectiveness. Secondly, in January 2018, a content analysis study was undertaken, scanning the most popular UK app stores (Apple and Google Play stores) and describing all available paid and free apps supporting hypertension self-management and examining their functionalities. A privacy and security assessment of potentially effective apps was also performed.
Key results: The systematic review included a total of 21 articles, evaluating 14 apps between them. This review indicated that apps have a generally positive effect on controlling BP. Due to inconsistencies in the design and quality of the articles, there is no decisive evidence about which of the functionality combinations are most effective. However, it is clear that apps are likely to be more effective when they have more

comprehensive functionalities. Most apps in this review were study-specific, that is, they were developed solely for the purpose of the study. This is in contrast to the scores of commercial apps available on app stores. Indeed, the content analysis study identified 186 such apps. There was a lack of evidence in relation to all available apps regarding their usability, effectiveness, and the involvement of health professionals in the development process. Furthermore, only few apps possessed comprehensive functionalities ($n = 30$). Most of them did not meet current criteria regarding data privacy and security and lacked a clear theoretical basis. These findings raise a serious issue for physicians and patients attempting to find a suitable app for the self-management of hypertensions. Eight apps were identified that appeared to be effective, whilst also meeting current standards of security and privacy levels.

Conclusion: Despite the wide availability of apps to support self-management of hypertensive patients, and a corresponding body of research into such apps, relatively few apps are effective in supporting self-management of hypertension and protecting users' personal data.

Keywords: App, Smartphone, hypertension, blood pressure, self-management.

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Developing an Intelligent Virtual Coach for Boccia: Design of a Virtual Boccia Simulator

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Background: According to the World Health Organization, approximately 15% of the worldwide population lives with some form of disability. The current trend indicates that these numbers will keep increasing during the following years. Having a disability can lead to social exclusion, therefore it is paramount to ensure that every individual with a motor or cognitive disability can be able to participate in society, to the largest extent possible. Thus, it is necessary to design and implement innovative strategies in order to tackle these issues by fighting segregation and promoting social integration. Boccia is a precision, strategy-based ball sport which has been part of the Paralympic games since 1984 and it is practiced in more than 50 countries worldwide. Originally, it has been designed for individuals with cerebral palsy, but the rules of the game can be easily adapted to individuals with other types of motor or cognitive disabilities. Besides, Boccia is a multiplayer game, which further encourages the interaction between the players.

Method: This paper presents an intelligent virtual coach for Boccia, which is currently a work in progress. This virtual coach will be able to provide tips to the user by suggesting the best possible position in the court where he/she can place the ball and how to execute the respective throwing movement. Furthermore, the suggested strategies are adapted to the current state of the game. This tool will be used to encourage individuals with different disabilities to learn how to play the game and to help shortening the learning curve, thus promoting physical activity. Furthermore, more individuals will be able to participate in the game and, since Boccia is a team-based game, the interaction amongst players with different disabilities can promote social rehabilitation, thus contributing for inclusion. Moreover, different types of sensors will be used on the players in order to acquire various bio-signals, which may trigger different virtual coach actions/responses. This data will also be recorded, so that relevant health indicators can be closely followed by a coach or a caregiver. The work developed so far focuses on the design of a Virtual Boccia Simulator, which allows to easily simulate various game situations, thus facilitating the training of the virtual coach's Artificial Intelligence algorithms.

Key results: The Virtual Boccia Simulator was successfully developed in Unity 3D. The current implementation allows the user to throw the Boccia balls from each of the six court positions, with the desired direction and force. Ball physics are also customizable. Of course, the setting of these parameters depends on the disability and the associated level. Additionally, a "free-camera" mode was implemented, which allows the placement of Boccia balls anywhere inside the court and the taking of screenshots to be used for the training of Artificial Intelligence algorithms.

Conclusion: Overall, this work in progress aims to encourage the practice of physical activity on individuals with disabilities by playing Boccia, independently of gender, race or religion. Furthermore, as Boccia is a social game, it can be used as a platform for inclusion, empowerment and promotion of social interaction.

Keywords: Boccia, Social Inclusion, Rehabilitation, Artificial Intelligence

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Special Thematic Session 8
Creating a Match: Supporting student participation across the educational continuum with technology

This special thematic session will be an interactive and engaging discussion on examining the role of assistive technology (AT) including universal design for learning (UDL) for students with impairments affecting their participation in educational-based activities. Research supports the use of AT for students with disabilities to access curriculum, enhance cognitive skills, improve communication and social skills, and to aide in independence with self-care and daily living skills. Students with disabilities that begin to use AT early in their educational learning can be more effective in accomplishing their educational goals and transitioning into post-secondary education with increased confidence and success than students being introduced to AT use later in their educational career. Universal design involves a whole systems approach from policy to infrastructure considerations to create a learning environment for all learners to achieve their dreams. Presenters will highlight the importance of addressing AT use across the educational continuum and examine the following areas: early intervention to support learning and child-family engagement, student success in mastering educational goals with a focus on outcome measures, environmental context considerations to support learning, promoting vocational success-the importance of addressing AT and UDL in transition planning for students. Presenters will use the Matching Person and Technology, Ecosystems, and the International Classification of Functioning, Disability, and Health (ICF) Frameworks to discuss the importance of addressing personal factors, environmental contexts, and feature matching of student and technology in the assessment and implementation process. Case scenarios across the education continuum will be used to enhance participant learning.
Chair: *Susan Zapf and Marcia Scherer*

Universal Design as a Catalyst for Transformation Across the Educational Continuum

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Background: A congress can represent many different things to many different people and as organizers of the Universal Design and Higher Education in Transformation Congress 2018 (UDHEIT 2018), our hopes were to allow two communities of practice share a physical space to discuss and debate the transformation of higher education. Each individual journey that the participants of the congress imparted, illustrated the importance and value of a forum for generous thinking – a critical ingredient in sparking innovation and change. The purpose of this presentation is to provide a joint reflection on the impact of this UDHEIT event on our learning – and to present a review of current thinking on how best to employ the principles of universal design at a systems level in a higher education covering the three scales of macro, meso and micro. The overarching framework of the congress was built around a range of key themes capturing the research interests of the diverse communities of practice – from the built environment, digital systems including assistive technologies, urban design and planning, community engagement to curriculum planning and delivery. The key questions to be addressed were at (i) Macro level – how do you influence policy makers and change society for the benefit of all citizens? (ii) Meso level what are the practicalities of developing and implementing policy within organizations and communities? (iii) Micro level how can individual actions and initiatives make a difference? This presentation provides an overview of the research presented by 140 speakers from 30 countries around the world. It provides evidence of innovation, research and critical change that is bringing about an inclusive educational experience for all learners
Method: A thematic review of the papers presented at the UDHEIT 2018 congress to demonstrate how universal design is influencing transformational change in higher education.
Conclusion: Framing Universal Design from a systems perspective enables diverse stakeholders to bridge the "Know-Do" gap. As a vital part of systems change the congress demonstrated, debated and discussed the three critical ingredients for transformation of the edu-

cational environment at an ecosystem level. These ingredients were new resources and materials, changing practices and changing beliefs to ensure an enabling rather than disabling environment for a diverse range of learners.

Keywords: Universal Design, Higher education, transformation, systems approach.

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Developing the Irish Matching Person with Technology (IMPT) to a multimedia format through a Universal Design process

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Background: In Ireland a national study in 2017 commissioned by the National Council for Special Education on the use of Assistive technology (AT) in education recommended that the AT assessment and the matching process should be developed based on the principles of universal design (UD) with an emphasis on pupils with severe and more complex needs. Many children have their own unique abilities and unique understanding of the world which standardised tests often fail to recognise. Exploring the needs of children with disabilities can mean traditional data collection techniques do not provide the framework necessary to investigate how technology and AT can support their needs. Most assessment tools use verbal or text based techniques to interview and assess, which can often position the child as a passive object and do not fully understand a child's experiences or their multiplicity of abilities and needs. This paper outlines the adaptation of the Irish Matching Person with Technology (IMPT) tool to a multi-modal (IMPT/MM) format through a universal design process to provide altnerative inputs, and presents initial findings in a case study series of children who have used the tool in a pre and post study.
Method: A central element of universal design is understanding through observation and ethnography, the experiences of the people, their own perception of their lives, their social interaction and their desired activities, interests, priorities and concerns. In this project the children and their parents were engaged in the whole process through observation, group discussions, focus groups, face to face interviews and engagement within the children in the classroom This was an iterative process developed over 18 months broken down into four stages based on the double diamond 4D design process of discover, define, develop and deliver.
Key results: Sixteen children with multiple disabilities took part in the project with a pre-assessment interview using the IMPT/MM, the children have multiple disabilities with significant learning difficulties. At pre assessment interview, through using the IMPT/MD tool, the children were able to self-identify activities which could be facilitated through AT use, however due to critical problems with service delivery, long waitlists, poor funding and a lack of expertise in AT, just eight children secured assessment. While many of the children are being assessed for one functioning impairment, mainly mobillity, other functional impairments are ignored. This paper presents the findings based on eight case studies, outlining the critical service issues. Work is ongoing to validate the instrument with the remaining 8 children and a further cohort of 10 children.
Conclusion: The use of IMPT/MM enabled the children to self-identify their AT needs, however the project has uncovered critical issues in the delivery of AT service in Ireland which has caused unaccetable delays in the provision of AT and a final report with recommendations will be submitted to the funding body.

Acknowledgement: This research is part of the ASSISTID programme, which is funded through a COFUND grant from European Union Marie Curie programme and the RESPECT charity

Keywords: universal design, assistive technology, matching person with technology, AT service delivery.

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Exploring the Role of Assistive Technologist within a Special Education Setting

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Background: High tech augmentative and alternative communication (AAC) aids remain underutilised and frequently abandoned within special education (SE) schools. Yet there is compelling evidence of both the benefits of early intervention and of the significant contribution these technologies can make towards improving outcomes for emerging communicators with communication disabilities. This study builds upon earlier ethnographic research that identified the cross-disciplinary role of the Assistive Technologist (ATist) as a solution to issues of technical support for pedagogy and co-ordination encountered in the field – a trained professional who might mitigate some of the problems described above by innovating novel solutions, boosting evidence-based practice, and enhancing cooperation between practitioners within the classroom environment. To date there had been no formal attempt to understand or define the ATist role in the SE classroom and this study's primary aim was to explore the role as a precursor towards developing a definitive framework.
Method: Approval was granted from the University Ethics Committee and an ethnographic study was undertaken in a SE school, with the principle investigator (PI) – an experienced AAC practitioner – embedded for five months within a class of primary school age children identified as having profound and multiple learning disabilities (PMLD). An exploratory mixed methods approach was adopted: A qualitative case study (exploratory single-subject design); supplemented by end of study semi-structured interviews with adult stakeholder participants and allied health professionals ($n = 6$) comprising teachers, speech language therapists, classroom assistants and one parent/carer. During the study, the PI worked as part of the team, adopting the role of the ATist, and acting responsively as a mediator between the teacher, focal AAC user and their assistive technology device. Content analysis was then undertaken of the collected data (field notes, transcripts).
Key results: The embedded approach facilitated familiarisation and relationship building. Data yielded support for insights attained in the earlier study, and – importantly – key empirical evidence was acquired, documenting the positive influence of the ATist role as a significant protagonist in coordinating, supporting and meeting pedagogical goals for high tech AAC users. These results represent a major contribution toward the framework currently under development – a definitive description of the ATist's role within a SE context.
Conclusion: The presence of an ATist enabled dynamic personalisation (eg. programming novel vocabulary "just in time") of the focal user's AAC device, which – coupled with frequent, contextual aided language stimulation – created a richer and more responsive learning environment for the focal participant, and concomitantly for staff and for other children in the classroom. The ATist also supported educators in developing tailored online learning activities, and addressing technical issues as and when they arose – both minimising disruption, and supporting a more holistic learning experience for the pupils. For future work, it is intended to complete and evaluate the nascent framework defining the ATist's role in a forthcoming study by eliciting feedback from subject matter experts.
Keywords: Human computer interaction, Augmentative and alternative communication, Early intervention, Special education.
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Assistive Technology in the University, Is There Still a Person-Technology Match?

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Background: The number of persons with disability who study at a university in Spain represents 0.52% of the university's students. That low prevalence is due to several factors: lack of information about Assistive Technology (AT), the low commitment from teachers, deficient accessibility and the self-concept of students with a disability. In this paper, the authors discuss the level of matching student and technology and the predisposition to technology use by university students with a disability, in general, and with Neuromuscular Disorders (NMD) and deafness, in particular.
Method: Results are presented from three studies done in different regions of Spain. The Survey of Technology Use (SOTU), and the Assistive Technology Device Predisposition Assessment (ATD PA) and Educational Technology Device Predisposition Assessment (ET PA) were the measures used and are part of the Matching Person & Technology (MPT) portfolio of assessments. The sample in first study consisted of 155 students with and without a disability; the second sample was comprised of 11 students affected by any

NMD and using wheelchair. In the third sample, 35 participants were students with deafness or hearing impairment (6 prelocutives/prelingual and 29 postlocutives/postlingual).
Key results: The use of specific instruments to measure outcomes, such as those in the MPT model portfolio of measures, is rare in Spain. Just three documented studies have used this tool. The percentage of students with disability in Spanish universities is low, mainly due to lack of accessibility, adaptations, and the absence of assistive technology. The predisposition to technology use, in general, has been positive (number of positive answers was higher than the negatives or neutral). In students with NMD, the scores regarding their match with their wheelchair had a mean of 44.17 (out of 50) and a median of 46.5. Thus, the wheelchair, as an AT, is viewed as benefitting the participation of persons with NMD in their educational activities. Participants scores reflected physical inaccessibility as a main barrier to the optimal use of their AT. Deaf people have very good experiences with technology, especially those with pre-lingual deafness. They rated the video call system as the best support.
Conclusion: There aren't significant differences between students with and without disabilities in regards to their preferences about the use of technology in general. Positive answers to SOTU questionnaire items predominate. The students with disabilities, in general, don't use a large number of ATs during their scholarly activities. The persons with NMD utilize their wheelchair their match with it is positive.
The application of the MPT model and its assessments in a population of 155 adult university students showed good validity and feasibility. This research has allowed for a translation and adaptation of the MPT instruments into Spanish versions.
Keywords: University, Education, Outcome measures, Assistive technology (AT), Matching person and technology (MPT).
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Outcome Effectiveness of Assistive Technology in Supporting Students' Mastery of Educational Goals

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Background: Assistive technology can be a catalyst in supporting students with disabilities to be successful within their educational setting and should be considered within each student's educational plan. The purpose of this quasi-experimental pre-post-test, non-control group research design was to measure the effectiveness of assistive technology tools used in the educational setting to support student success through quantitative analysis using the Student Performance Profile scores.
Method: Twenty-three Assistive Technology Team Evaluators using the MATCH-ACES Assessment evaluated 35 students with disabilities for assistive technology needs. Data was collected during the 2010 and 2011 school years. Specific educational goals were identified for each student and the student's performance pre-scores on these goals were collected. The recommended assistive technology was provided to students with training and students used the technology for a four-six-month time period. Student performance post-scores on the targeted goals were collected and data analyses on outcome effectiveness was completed.
Key results: A significant improvement in student performance was found for this cohort on their educational goals one ($p < 0.001$) and two ($p = 0.001$). A large effect size was found indicating that participants improved their performance on the educational goals related to assistive technology use (goal one [$d = 0.86$], goal two [$d = 0.97$], indicating clinical significance. ANOVA analysis was used to determine if the level of AT use contributed to the student's performance. A Friedman analysis of variance was used due to parametric assumptions not being met (ordinal data). Assistive technology was found to be a significant factor in contributing to the success of student performance ($p < 0.001$). The study was found to have adequate power (power was set at $\beta = 0.80$, effect size: < 0.80).
Conclusion: Assistive technology tools were found to significantly impact students' progress on their educational goals. When students are matched and trained to use assistive technology based on the student's needs and preferences; assistive technology can aid students in making progress on their individualized educational plans and support academic success.

Keywords: Assistive Technology, Students with disabilities, Matching Assistive Technology to Child (MATCH) Assessment, Special Education, Assistive Technology Services.
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Standardizing the Procedures, Improving our Listening to the Needs of the Individual User

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Background: Knowing which elements could guide the development of policies, systems, and service delivery procedures is essential to develop an assistive technology (AT) provision standard, to connect services and outcomes, and compare data for AT in Europe and across the world. As stated by the GREAT conference in Geneva (Global Research, Innovation and Education in Assistive Technology) held in August 2017 as part of the World Health Organization's GATE initiative, identifying what constitute the international framework for the provision of AT worldwide is an urgent WHO task (de Witte et al., 2018).
Method: Developed in the light of the Matching Person and Technology (MPT) model (Scherer, 1998), an ideal model of AT assessment process that gathers the most recent scientific developments in AT assessment and provision is here presented, as it is described in the popular text, Assistive Technology Assessment Handbook, 2nd Edition (Federici and Scherer, 2018). The Matching Person and Technology Model and accompanying assessments have been found to have very good psychometric properties and have been validated by a number of studies. They have been translated into eight languages. Several derivative measures have been developed. In this presentation, we will outline how the AT assessment process can be applied in practice to re-conceptualize the phases of an AT delivery system according to the ICF's biopsychosocial model of disability. The model provides reference guidelines for evidence-based practice, guiding both public and private centers that wish to compare, evaluate, and improve their ability to match a person with the correct technology model. The present contribution to this special thematic session can foster discussion among health practitioners and technology providers (occupational therapists, physiotherapists, rehabilitation engineers, speech-language pathologists), as well as undergraduate and graduate students in these areas.
Key results: Successful assistive technology service delivery outcomes highlighted well the effectiveness of the ideal model, here presented, of AT assessment and delivery process, as demonstrated in several studies (Federici et al., 2015). The environmental assessment procedure brings clarity to measures of accessibility, universal design, and sustainability, and captures well the three perspectives on the interaction between the person and AT in the user's environments.
Conclusion: This model can be used by professionals to check the functioning and to (re-)conceptualize the phases of an AT delivery system according to: (i) the ICF's biopsychosocial model of disability; (ii) the seven steps mentioned by the AAATE as relevant and adequate for any service delivery process; and (iii) the MPT model that ensures that the provision is person-centered and not product of service-centered. This model of service delivery, therefore, intends to express, in an idealized and essential form, an assessment process where persons and their environment are at the core of process, products, personnel, and provision.
Keywords: Assistive Technology Assessment process (ATA model), Matching Person and Technology (MPT) model, ICF.
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Special Thematic Session 9
Good Practices in AT Service Delivery

Since the publication of the 2012 AAATE/EASTIN Position Paper on AT service delivery, significant advancements have been carried out in several Countries to improve national policies and service delivery systems. Several new challenges have been posed by the recent changes in the political and socio-economic landscape, as well as the fast technological advancement. The theme "AT policies, systems, service provision models, best practices" has been recently indicated (2016) by the WHO (World Health Organization) among the five research priorities in the Global Priority Research Agenda of the GATE initiative (Global Collaboration on Assistive Technology); it will also be among the topics of the Global Report on Access to AT to be published in 2021 as mandated by the WHO Resolution "Improving Access to Assistive Technology" Issued on May 24, 2016. Within this framework, work is in progress worldwide to develop service delivery models, requirements and standards, drawing on the analysis of best practices either in countries with estab-

lished welfare systems or in developing countries. This session intends to give a feeling of this ongoing work and contribute to the debate by presenting some best practice examples from various Countries; by fostering discussion on commonalities, differences and trends; by helping learn from each other and get inspiration for improvements that can increase access to appropriate assistive technology for persons who need them.
Chair: *Renzo Andrich*

Proposal for Collaborative Assistive Technology Provision with Digital Fabrication

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Background: Assistive technology (AT) services are essential for adapting assistive devices to the individual needs of users with disabilities. The main AT service is selecting or adjusting devices. If neither selecting or adjusting assistive devices are suitable for individual needs, production or remodeling methods can be applied. However, AT services often depend on the empirical knowledge and experience-based skills of individuals or the regional community. Meanwhile, three-dimensional (3D) printing technology is a well-known type of digital fabrication that is expected to result in new value creation. For AT services, we attempted to apply 3D printing technology to actual cases and proposed effective applications. Various case studies have reported the use of 3D printing for supporting special needs education, making self-help devices, and designing 3D printable prosthetics in rehabilitation facilities. Accordingly, human resources development that can take advantage of digital fabrication is required to perform better AT services in local communities where users with disabilities live. In this study, collaborative AT service was proposed through the development of an online database for sharing information about the techniques and knowledge on providing assistive devices to users and a training program for digital fabrication.
Method: The Support System for Assistive Technology (SS-AT), an online database of assistive devices produced using a 3D printer, was created with a cloud database. Each record of the SS-AT contains not only 3D printable files on assistive devices but also tips and empirical information from experts and user feedback including users with disabilities, AT specialists, therapists, designers, and makers, etc. There are two kinds of 3D printable files: those for a parametric approach and an explicit approach. The parametric approach enables the redesign of the shapes of the device by modifying its parameters. The explicit approach enables the design of complex surface shapes to fit to the other parts. The tips and empirical information help adjust parameters and provide suitable AT services. The contents of the training program to learn digital fabrication for AT services were also planned and hands-on workshops were conducted.
Key results: In the SS-AT, various 3D printable files with tips and feedback have been uploaded: joysticks for operating electric wheelchairs and pointing devices, straw clips, keyguards, self-help devices, and shapes of dishes. Although SS-AT access currently requires registration, users can collaborate with each other as well as download files. In the workshop, participants include physical and occupational therapists, special needs education teachers, social workers, caregivers, local volunteers, and AT users with disabilities. They experienced printing an assistive device using 3D printers and designing assistive devices using 3D CAD. Participants also brainstormed self-help devices and shared individual needs and opinions with each other. The results were promising for the development of human resources who perform AT services by remodeling and producing for users with disabilities in local communities.
Conclusion: This work has the good potential to increase AT services in local communities and help share individual experiences, knowledge, and techniques between distant regional communities. It hopes to contribute to the creation of an AT service system using digital fabrication.
Keywords: Digital Fabrication, 3D Printer, Community Welfare.
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Assistive Technology Service Delivery in Rehabilitation Context

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Background: The Italian National Health Service structures the assistive technology (AT) service delivery process in six steps: *planning*, *prescription*, *authorisation*, *delivery*, *inspection* and *follow-up*. Prescription, authorisation and delivery are strictly regulated, under the responsibility – respectively – of a specialized medical doctor, the Local Health Authority and the supplying company chosen by the user. The way to carry out all other steps is left to the service providers. Here we report on the service model implemented by the Fondazione Don Gnocchi (FDG) rehabilitation Centres, according to the conceptual framework developed by the Italian GLIC network of AT Centres.
Method used: This model is based on AT specialized units called *SIVA*, where individual AT interventions are carried out in three steps: *assessment* (leading to the prescription of the appropriate assistive solutions), *verification* (checking the correct implementation of the solution provided) and *follow-up* (measuring its outcome in the long run). Each intervention is tracked through a purposely-developed computerized form (SIVA Form) and three validated instruments: KWAZO, IPPA and QUEST. Each SIVA has an AT showroom, a team of therapists specializing in AT, and can rely on engineering support by a central unit called SIVALab.
Key results: Here we describe the model though an example chosen from the database of the SIVA interventions: Giorgia (fictitious name), a 30-years-old lady with quadriplegia who resides in a residential care facility. The *assessment* was aimed at finding a solution to enable Giorgia to call assistance when lying in bed during the night. The assessment team included a SIVA therapist, a SIVALab engineer and a nurse of the residence. It was found that some residual movements of the left hand and head could be used to operate remote controls. Different solutions were tried out until identifying the most appropriate one: a head-activated pressure switch, positioned near the head through an articulated arm fixed to the bed, and a cable adapter for connecting the switch to the wall socket of the residence call system. An assessment report was compiled through the SIVA Form to recommend this solution. *Verification* was carried out as soon the new solution had been implemented by the care facility. The system had been purchased and installed as recommended. Baseline data for outcome measurement were collected through the KWAZO and IPPA-1 instruments. Three months after, a *follow-up* interview was performed, administering the IPPA-2 and QUEST instruments. Giorgia perceived the solution as very effective (IPPA score $+15$, on a -20 to $+20$ scale), was happy with the assessment/provision service (KWAZO score 4.29 on a 1–5 scale), and was very satisfied with the devices (QUEST score 4.63 on a 1–5 scale). The cost was borne by the residence (€ 660).
Conclusion: Giorgia is an example of how AT interventions are carried out by the SIVA units, and monitored until measuring the outcome in real life situation. This model is used mostly for complex cases where multi-disciplinary work and significant case management effort are needed to ensure consistency of the AT solution with the persons' rehabilitation programme.
Keywords: AT service delivery, AT assessment services, Good practices.
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International Classification of Functioning (ICF) and ISO 9999: 2016 Based Combined Evaluation-effectiveness and Reasoning

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Background: Selection of optimal assessment tool of assistive technology has been talking point among the professionals for years. Standardized tools include often evaluation of limited performance areas in Activity Daily Life skills. Looking for unique basement how to get overview what activities the person with a health condition can do in a standard environment and what they actually do in their usual environment, seems ICF and ISO 9999:2016 combined assessment to be most resultful. State coordinated pilot project is currently in action in Estonia about combined ICF and ISO 9999 assessment prototype development. Current study highlights the results of Estonian version of combined ICF and ISO 9999 based functional assessment. The customer's capacity and performance expressed in following terms: structures (s-codes), functions impairments (b-codes) and activity-participation limitations (d-codes).
Method: 10 persons at the age gap between 35–55 years with Sclerosis Multiplex were selected for

the study, 5 males and 5 females with disability affecting time average 6 years. All participants evaluated as the persons with partial work ability, assessment is based on ICF. Study participants expertise's analyzed about determined ICF codes. Based on work ability assessments participants impairments of functions belonged to the b2, b4, b5 and b7 domains. Activity limitations belonged to the domains d4–d8. All study participants used daily during walking activities lower extremity assistive technology device L300 Go Orthosis, belonging to ISO subcategory 06.15. (Functional neuromuscular stimulators and hybrid orthosis). Before usage and after 3 months of using period of L300 Go device assistive technology specialist assessed participant's motor capacity and performance by ICF and ISO 9999:2016 combined prototype. Overlapping did not exist in 2 ICF subdomains of functioning (b1, b3) and in 2 subdomains in activities (d1, d9). Based on the findings assistive technology specialist created participant's ICF graphic profile with and without assistive technology device.

Key results: ICF based work ability assessment and ISO 9999:2016 based assistive technology assessment are not entirely compatible. There were differences in 2 domains of Functions and in 2 domains of Activity and Participation. ICF and ISO 9999:2016 combination for assessment of person's participation restrictions and activity limitations is most precise. The original ICF Core-Set enables to create functional and activity profile of customer. ICF and ISO 9999:2016 combined assessment enables to create holistic functional profile of customer abilities with and without assistive technology device.

Conclusion: International Classification of Functioning and ISO 9999:2016 based combined assessment is beneficial for setting goals and performing holistic rehabilitation as it enables to focus simultaneously to the customer's functional performance and capacity. Customers graphic profiles created by two-component assessment are valuable and synoptic data sets of customer's functional abilities and skills.

Keywords: Functioning, Work ability, Performance, Capacity.

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Exploring SMART Technologies: The Value of Tailored Sessions

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Background: There is an ever-expanding range of mainstream and dedicated technologies on the market. In particular, innovations such as SMART technologies (Sensing, Monitoring and Automatically Responding Technologies (SMART) provide increasing opportunities for older people and people with disabilities to manage and monitor their homes, maintain safety and security, promote health, navigate through environments, and remain connected to their communities. However, it is often difficult to keep abreast of new developments and understand what these technologies can offer. A qualitative study was undertaken to examine the experiences of 12 people with a variety of abilities who partnered with a health professional to explore the opportunities afforded by SMART technologies. This presentation reports on the experiences of their individualized SMART technology exploration session, including their awareness of these technologies, motivations for acquisition, and perceived barriers and facilitators to the uptake and use of these technologies.

Method: Participants were provided with an individualized session to explore SMART technologies and evaluate the opportunities these afforded them. The sessions were audio recorded and transcribed verbatim. Following the session, participants were phoned and asked a series of questions relating to what worked / didn't work well in the session in terms of understanding what was possible and what these technologies might offer. The participant's awareness of SMART technology, motivations for acquisition, and perceived barriers and facilitators to uptake and use were also examined through a thematic analysis of the session and interview transcripts.

Key results: Twelve people with disabilities were involved in the study. The participants ranged in age from 12–74 years and had a variety of disabilities and health conditions including congenital (1) and degenerative (4) neurological conditions; traumatic injuries (2); vision impairment (1); three other health conditions (4).

Participants reported that a comprehensive overview of SMART technologies presented in functional categories helped them to understand what was possible and the potential value of these technologies to their lives. Expectations of how well things were currently being managed often changed during the session, as

people were made aware of the contribution SMART technologies could make. Participants reported that demonstrations of the technologies helped them understand the functions they offered. Tailoring information to each individual's specific requirements and circumstances kept participants engaged and wanting to know more.

The main influences on awareness and knowledge of SMART technology were reported to be general level of interest in technology and avenues for gaining information. Motivations for acquiring SMART technologies included future planning, leisure participation and social interaction, portability, personal safety, and independence. Barriers and facilitators to uptake and use, included reliability and durability, lifestyle fit, cost, learning to use SMART technology, ease of use and environment and contextual factors.

Conclusion: Tailored SMART technology sessions which overview the range of technologies in functional categories extend an individual's understanding of how these technologies can enhance his or her life and create new opportunities. These sessions should also give due consideration to people's motivations for exploring these technologies and perceived barriers and facilitators in order to promote uptake and use.

Keywords: SMART technologies, tailored session, uptake and use.

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What are They Doing and What are They Measuring? A Scoping Review on the Technological Interventions and Ageing in Place Outcomes Allied Health Professionals Use

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Background: Technology is often recommended in the scientific literature and by governments as a way of supporting older adults to "age in place". That is, to live independently in a way of their choosing. Despite such emphasis on technologies, and the exponential rate in technology development and availability, there are still many gaps in the use of technologies within the aged care sector. Specifically, little is known about how allied health professionals working with older adults deliver technology to facilitate their client's independence, with the majority of research focusing on the development and accessibility of technologies rather than the impact on person-centred outcomes associated with ageing in place.

The current study thus explores (1) how allied health professionals are currently using technologies with older adults, and (2) the outcome measures used to the assess the impact of technology on ageing in place.

Method: A scoping review was conducted using recognised methods. Studies were included if they used a quantitative design to evaluate the effect of a technology which may be recommended by an allied professional and who's outcome was to increase an older adult's independence, wellbeing, confidence or participation in everyday activities. 12 relevant health databases were searched for peer reviewed, intervention studies, published between 2008 and 2018. Key search terms included, technology, older adult, community, and their synonyms. Articles were independently screened and assessed for inclusion in the review. Key data were then extracted from each included study, with the findings from each study compared for similarities and differences.

Key results: Forty-seven studies were included in the review. Many of the excluded studies focused solely on uptake and acceptability of the technology or on clinical outcomes, rather than improving outcomes related to ageing in place. Human interactions and social connections appear important, particularly in learning and using a new technology. Most of the studies focused on a particular technology with few studies focusing on the individual goals of the older person in relation to ageing in place.

Conclusion: Peer reviewed studies have been published evaluating the effect of technology on some ageing in place outcomes. This study provides an insight into the current techniques and practices of allied health professionals when using technology as an intervention, and the types of outcome measures used in relation to ageing in place. These findings can inform the design of a meaningful and effective process for allied health professionals to use when considering technological interventions for older adults. In practice it is important to work with a person-centred approach, matching technological interventions to suit the goals of the older person and the context.

Keywords: Aged, Technology, Health Professions, Community, Outcome Measures.

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Assistive Technology Provision in India: Challenges and solutions

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Background: Provision of Assistive Technology (AT) to a country of 1.35 billion people; 70% of them spread over 640,867 villages is an enormous challenge. Even if just a third of the 26.8 million of the estimated number of persons with disability (PwDs) in India needed AT, it is still 8–10 million people that have to be reached. Despite mammoth efforts taken by the government, complemented by private business enterprises, not-for-profit and philanthropic organizations, AT provision in India is still fragmented and mostly unregulated. Access to good quality, affordable AT, remains a dream to many of the persons with disability. The objective of this paper is to present the various efforts and programs developed by the government and the private sector, its benefits and challenges and suggest a simpler model that could be effective and efficient to fill the gap of AT needs in India.
Method: The different models of AT provision in India was reviewed using a combination of a desk review, literature search and sharing of learning from being an implementer of the government District Disability Rehabilitation Centre over the past five years. This has given the opportunity to gain rich insights on AT provision through multiple interactions with PwDs, grass root level rehabilitation workers, government officials, private sector and other organizations who are involved in AT provision and rehabilitation.
Key results: The Ministry of Social Justice and Empowerment (SJ & E) proposed to establish the District Disability Rehabilitation Centers (DDRCs) to serve as "Hubs for comprehensive rehabilitation" in all 640 districts in India. The provision/fitment of assistive devices, follow up/repair of assistive devices is an important component of the DDRC. Besides the DDRC, most ATs have to be obtained through the Assistance to Disabled Persons (ADIP) Scheme. However, the process of procuring ATs through this scheme is extremely complex with extensive documentation, upfront payment by NGOs, prolonged turnaround times, delays in reimbursement and poor quality of ATs supplied. The Artificial Limbs Manufacturing Corporation of India (ALIMCO) supplies assistive products that come is standard sizes and are not "tailor made" to the needs of the disabled, leading to non-utilization and waste of resources. The DDRCs themselves are plagued by lack of sufficient funds, adequately trained manpower, materials and poor co-ordination at various levels and sectors. The private sector on the other hand has contributed considerably in research and development of various assistive products, but they are islands of excellence in a sea of poverty and inaccessibility.
Conclusion: AT provision through the DDRC model could be strengthened with more political will, infusion of more resources, improving the competency of staff, better monitoring, supervision and better collaboration with the NGO/private sector. Simpler processes in obtaining ATs through the existing schemes would improve access and affordable to the majority of the PwDs. The social, economic, cultural diversity, poverty and inequity of India contribute to the complex challenges in AT provision in India.
Keywords: Assistive Technology, India, challenges, solutions, DDRC.
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Assessing the Outcome of Individual Assistive Technology Interventions

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Background: Assistive Technology (AT) outcome is indicated by the World Health Organization among the five top priorities in AT research. In recent years several measurement tools have been developed and validated in many languages. One of today's key issues is how to routinely include outcome measures within the service delivery process, in order to capture the effectiveness of the intervention in a sustainable manner (i.e. compatible with organization, human resources and budgetary constraints) and detect possible cases of ineffectiveness that require further intake.
Method: 57 persons (27 women, 30 men, age 5–88 average 59) – who had received AT solutions after in-depth assessment in specialized AT units of rehabilitation centres – were recruited to undergo a verification/follow-up process. Each assistive solution included a range of products and environmental adaptations to facilitate mobility, communication and self-care in daily life at home, work or school. Overall 150 products were provided, mainly manual or powered

wheelchairs, seating systems, walkers, hoists, computer access interfaces, bathroom devices and communicators. Verification included: 1) inventory of the products composing the assistive solution; 2) technical inspection to check proper installation/fitting; 3) KWAZO (Quality of AT Service Delivery Process) questionnaire about the user's and the caregiver's perceived quality of the assessment and provision service; 4) IPPA (Individual Prioritised Problems Assesment) first interview to detect their expectations with the received AT solution and 5) WHODAS (WHO Disability Assessment Schedule) 12-item interview to detect the user's disability profile.

A follow-up interview was carried out 3 to 6 months after verification. It included 1) data on the product usage; 2) possible problems occurred in usage; 3) IPPA second questionnaire to detect how far the user's expectations had been met; 4) QUEST (Quebec User Evaluation of Satisfaction with AT) to detect the user satisfaction with each product.

Key results: Most persons had severe disability condition (WHODAS score 33–100%, mean 67%) especially in the mobility area. All persons expressed high satisfaction with the process (KWAZO user score 3–5, mean 4,75; caregivers score 4–5, mean 4,79; in a 1 to 5 scale); most persons perceived their AT solution as effective (IPPA user score $-5{,}8$ – $+20$, mean $+8{,}45$; caregiver score $+0{,}83$ – $+16{,}43$, mean $+9{,}14$; in a -20 to $+20$ scale); most person scored the products included in the AT solution as more than good (QUEST user score: 2–5, mean 4,49; caregiver score 3–5, mean 4,55; in a 1 to 5 scale). Three cases were found ineffective (IPPA $<= 0$); the failure reasons being, respectively 1) unexpected worsening of clinical condition 2) changes in living environment and 3) technical inadequacy of the provided products.

Conclusion: This method proved effective in measuring the outcome of AT interventions, and distinguishing among successful cases, unsuccessful cases (therefore needing to be looked after again) and "neutral" cases (where seemingly no improvement was achieved). More cost-efficient tools should be designed for the follow-up interview in order to make it sustainable within the service delivery process. Currently, work is in progress to routinely include this method in the service protocol of these rehabilitation centres.

Keywords: AT Assessment, AT service delivery, AT Outcome measurement.

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Assistive Technology Service Delivery models in the Netherlands

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Background: Since 2002, models to guide the Assistive Technology Service Delivery (ATSD) in the Netherlands have been implemented with the aim to organize the provision of AT in a more client-centered way. Due to the fact that the funding of AT is regulated by different laws and statutory rules, ATSD is perceived as very fragmented and not easy to oversee. Not only the type of AT but also the individual situation of the user and the setting of use determine which law or rule is applicable. The objective of this paper is to present the developments, recent trends and current practice of ATSD in the Netherlands, including advantages and disadvantages as identified by different stakeholders involved.

Method: A desk research was conducted by Internet search, with a focus on websites and documents of the Dutch government, knowledge institutions, the Netherlands Organization for Health Research and Development, and a large Dutch patient organization. Additionally, an invitational conference was held and 60 stakeholders representing experts in the field of ATSD, such as users, policymakers, researchers, suppliers, and practitioners with a variety of professional backgrounds were consulted, using a metaplan method.

Key results: Four main laws and corresponding executive authorities are involved in the provision of AT.

On the one hand, the Social Support Act and the provision of AT based on the ICF offer advantages compared to the previous situation in which a list of AT products existed that showed which products could be funded by indication. Now a person's needs in functioning, desired activities and participation form the starting-point to realize an optimal match between the person and a specific product, based on a program of requirements. Stakeholders are provided with the possibility of choice, and innovations in the field of AT are facilitated. Current models of ATSD emphasize the importance of trying-out, instruction, training, and user-centered assessments during the evaluation and follow-up. On the other hand, AT services are delivered at dif-

ferent places with no coherence. This is problematic when it comes to transitions between different care-settings (e.g. from hospital to a rehabilitation ward of a nursing home and finally, going back home) as different laws and regulations are involved. This renders the ATSD quite complex and time consuming. The same holds true for situations that demand a combination of AT devices which are funded by different executing authorities. An example is a dynamic arm support mounted on a wheelchair. Furthermore, the potential of AT is not used fully. One reason for that is a lack of awareness of the possible benefits of AT and different types of AT solutions, and missing objective information and protocols to guide their selection. Another reason is that the preventive or supportive use of AT by (in)formal caregivers is hindered by the conditionality of the Social Support Act, with costs being decisive instead of AT's added value.

Conclusion: Despite the identified drawbacks and deficits in daily practice the underlying user-centered principles of currently used ATDS models could be recommended as good practice in ATSD.

Keywords: Assistive Technology Service Delivery, ICF, user-centered.

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Special Thematic Session 10
Play, Children with Disabilities, and Robotics. State of the Art and New Developments

Play is the crucial activity through which children acquire psycho-motor, cognitive and social competences. Children with disabilities (CwD) may face many barriers to play, such as inaccessible environments and toys or adult attitudes often prioritizing rehabilitation and/or educational goals rather than to exploit children's ability to freely act and participate. Robotics has long faced this topic by developing robotic toys, assistive technology to enable play, and social assistive tools for the play of CwD. Robots can support both the activity of playing and the collection of data about the activity of CwD, possibly offering to the caregivers or companions the chance to develop new playing activities. Often, robots provide new opportunities of play that could be exploited to obtain interesting achievements. How robots can support play for CwD? What robots can bring to play for CwD? What products are available andare being developed? Is accessibility a hot topic? What developments are awaited to radical change and support CwD's play? The STS will show the work of some prominent groups working in the field, sharing the idea that CwD must have the opportunity to play autonomously the type of play they can/wish/need to grow up fully and happily. In particular, it will present: prototypes of new toys, augmentative mobility and augmented manipulation enabling children's autonomous play, experimentations of mainstream robots in school and in rehabilitation contexts, together with Guidelines on accessibility and usability of robotic toys. Inclusive contexts of play will be discussed too, showing how robots could improve inclusiveness.

Chair: *Serenella Besio*

What Is Play in Robotics Today?

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Background: Play is an innate, internally driven and evolving activity, crucial for children to acquire psycho-motor, cognitive and social competences. Despite being a right, it is far from being achieved by Children with Disabilities (CwD), who may face many barriers to play, such as inaccessible environments and toys or inadequate adult attitudes. Robotics has long faced this topic, by developing toys, assistive technology and social assistive tools for the CwD's play; here, play is interpreted as an unavoidable mean towards health, rehabilitation, educational scopes. Do these studies share a unique definition of play? What kind of awareness do they show on the different play types and characteristics and their relationships with the different ages in life? Last, are these studies comparable on a common basis, so that the field of play for CwD can steadily grow and acquire new knowledge? This presentation aims at giving an answer to these questions, according to the COST Action "LUDI – Play for CwD" (2014–2018) framework. Through the work of 100 European researchers and professionals, LUDI created a comprehensive theoretical background on the theme of CwD (Besio et al., 2017; 2018; Encarnção et al., 2018), to support further transdisciplinary research. By analyzing the studies and products found in the literature, it will be possible to propose some innovative reflections on the possible roles of robots for the CwD' play, and on awaited developments to produce a real advancement in the field.

Method: The last ten years (2009–2019) Proceedings of six important international robotics conferences

(EPIROB, HRI, ICRA, IDC, IROS, ROMAN) have been searched with the keywords "child" AND "play" OR "game", to know: a) the distribution of the related studies along the years; b) how many studies are addressed to children with disabilities (and what kind of impairment); c) what definition and/or theory of play is adopted, if any; d) what role is attributed to play and what system abilities are implemented for this purpose.
Key results: After relevancy check, 112 studies were found, with two peaks around the years 2013–14 and 2016–17; 19.6% are devoted to CwD (half to autism spectrum disorders). ROMAN, IDC and HRI are the most represented; 3 keynote speeches have been devoted to child's play (one to CwD). About half of the articles presents prototypes, the other ones adopt existing robots in original experimentations. They mostly address human-computer interaction aspects, mainly emotional, on the two sides; implemented relationships include the robots as companions, tutors, tutees, co-players. No article proposes a definition of play, 3 refer to play types. Health and educational topics are highly represented, for children with and without disabilities. Unexpectedly, one keynote speech was devoted to play for the sake of play.
Conclusion: The need for the adoption of a shared framework on child play, particularly for CwD, is testified by these scattered studies facing the topic from different perspectives without taking advantage from the others' results. By applying the LUDI approach, the presentation will show the most crucial deficiencies in the field and will advance some proposal for future implementation.
Keywords: Play, Children with Disabilities, Robotics.
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Simple Robots for Simple Play: Exploiting the Resources in Real Situations

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Background: Play is a right and a tool for development for everybody (Besio, 2017). Physical, interactive objects, i.e. robots, can provide tools engaging the player in a pleasurable activity. Pleasure and engagement come from the right mix of challenge and reward (Csikszentmihalyi, 1997). Complex and expensive devices are not needed for this: well-designed devices exploiting appropriate sets of signals and cause-effect relationships are enough to provide effective and interesting play experiences. A key modality to obtain these devices is to co-design the robot, involving players and their care-givers, which provide needs and desiderata, together with designers and technicians that can provide technological solutions. We developed several robots to be used by people affected by NDD (http://playbot4all.polimi.it). As an example, we present here Scimmiottondo, a monkey plush, having two metal hands. When touching both the hands the robot starts singing a typical Ring-around-the-rosey song. This can also be obtained when a set of people forms a circle including Scimmiottondo. In this way, it has been possible to include up to 10 people with different NDD, together with normally developed people, and therapists in a play activity exploiting attention, turn-taking, and physical contact. Scimmiottondo also includes an accelerometer, and, if it is mistreated in any phase of the game, it can start screaming. Moreover, if it is caressed on he top of the head it can sing a special song.
Method: The design of the robot was started by mentioning to a psychologist some technical possibilities, recognized as potentially interesting, and then the robot was co-designed with a care center. The participants to the trials were recruited by their caregivers. Each session started by a free interaction with the robot, aimed at discovering its capabilities and experiencing cause-effect relationships. Then, it was introduced as a possible companion for the Ring-around-the-rosey game, and the players had their moments to autonomously try what happened when they formed the complete circle or opened it, taking turns to experience to obtain the desired effect (singing or stop singing). Scimmiottondo was used in 10 sessions including 6–10 people with different NDD (medium functionality, aging from 16 to 42), 2–3 therapists and 1–3 normally developed people. Results were collected by interview from therapists.
Key results: Therapists reported the success of the experience in activating the game and stimulating appropriate interaction even in subjects usually refusing physical contact or having problems in managing turn-taking. Scimiottondo could focus the group activity also in repeated sessions, thanks to its appropriate engaging level.
Conclusion: Even very simple, cheap robots, such as the ones we designed to implement simple cause-effect relationships, can produce interesting experiences with people with different NDD. Critical issues include the perception of signals and the exploration of cause-

effect relationships; these call for the selection of appropriate signals, which should be reliably perceived and properly produced by the robot. The basic functionalities can be discovered by free exploration and can make also unexpected behaviors arising, a sign that NDD players can exploit their inventive power and show their hidden abilities.

Keywords: Play, Robot, Interactive system, Co-design, NDD.

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Play and Augmentative Mobility: the INMAC (INclusive Mobility for All Children) Vehicle

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Background: Children with Cerebral Palsy (CP) usually do not have the possibility of fully engaging in Play activities, mainly due to their functional limitations that lead to severe restrictions to perform manipulation and mobility events. For many years, activities of independent/augmentative mobility in Children with Disabilities (CwD) have been performed through the use of powered wheelchairs available in the market. However in the same markets, and with very few exceptions, there wasn't available any equipment to specifically provide augmentative mobility with the main objective of allowing very young CwD to engage in Play activities, adequate and/or adapted to their age levels. As a consequence, and in order to overtake some of the functional limitations faced by children with severe disabilities when they want to be involved in Play/Mobility activities, a R&D Project was setup with the main objective of providing independent mobility to CwD, with an emphasis on CP Children. As a result of the project, a special vehicle – INMAC INdependent Mobility for All Children – was developed and a few industrial prototypes of that vehicle were produced.

Method: INMAC is the practical outcome of an international R&D Project developed in order to fabricate a working prototype of a vehicle that could allow any child aged from 1 to 6 years old, namely those with severe disabilities, to engage in Play. INMAC is equipped with an array of ultrasonic sensors that not only avoid obstacles, but also provide feedback to the enduser of the physical environment where it is used. The vehicle can be totally controlled by the child through a specifically developed console and/or any AT interface available in the market. Five levels of use/activity can be setup, from a first level where the vehicle "takes over" the mobility tasks to be performed, until a fifth where it is the child that takes full control of the vehicle. Several prototypes were developed and tested in Rehab Centres mainly with CP children, and finally an industrial prototype (ready to be fabricated and go to the market) was developed, allowing any of the specific AT interfaces existing in the market (direct or indirect selection) to be used. The vehicle comes with a specially developed software that not only allows five levels of use/activity to be setup, but also allows the acquisition of many important data both from the vehicle as well from the specific interface used by the child. A protocol was developed for the tests of the INMAC, that mainly took place at a specialized rehab Centre for Cerebral Palsied Children, in Lisbon, Portugal.

Key results: Preliminary conclusions of the tests, showed that not only the children were able to be fully engaged in play activities despite their severe functional limitations, but also it contributed to the acquisition of psyco-motor, cognitive and social competences to those children.

Conclusion: Further tests are planned at an international level and with children with other disabilities than only PC children. Possibility of fabrication of many more vehicles to be available in the international market, are one of the outcomes of this project, contributing for the availability in the overall market of specific AT solutions for independent mobility.

Keywords: Children with Disabilities and Play, Augmentative Mobility, Independent Mobility.

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Mainstream Traditional or Robotic Toys: Which of Them Better Supports Playfulness in Children with Disabilities?

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Background: Play is the main drive for development and is fundamental for physical, cognitive and social development (Piaget, 1945/1972; Vygotsky, 1976). Playfulness is the child's 'disposition to play' (Barnett, 1991). Playfulness can allow to discriminate between play for the sake of play and 'play-like' activi-

ties (Visalberghi, 1958), which occur when play is used as a means to achieve 'other' purposes, such as learning or skill improvements.
Children with disabilities can experience limitations and functional problems (intellectual and motor limitations, speech disorders, sensory disturbances, emotional and social difficulties; Tingle, 1990). For these children, play can be limited because of environmental and contextual barriers (Besio, 2017); moreover, play is often used as a means for rehabilitation or educational purposes. Thus, children with disabilities are often prevented from playing for the sake of play. Toys, and specifically robotic toys, can offer interesting solutions to overcome the limitations of play activities and to support Playfulness (Skär, 2002). The project GioDi-1 (2014–2015) showed that robotic toys could support play and playfulness in children with physical impairments (Bulgarelli et al., 2018). The project GioDi-2 (2017–2019) directly compared the impact of similar classical vs robotic toys on the child's playfulness. The current study reports the first results of GioDi-2. The hypothesis was that children would obtain higher Playfulness scores when using robotic toys compared to classic toys.
Method: The sample consisted in 10 children (7 girls, 3 boys; mean age in years = 9.24, SD = 2.51; min = 6.05 years, max = 12.73) with intellectual disabilities; three children had also physical impairments. Data were collected in Fall 2018; each session was videotaped. Children were observed at school, in a separate room, during three sessions, playing with an educator with six different toys: classic and robotic caterpillar, classic and robotic dragon, classic and electronic ball. Fifty-eight sessions were analysed (one child refused to play with the robotic dragon, and one child with the classic caterpillar). Two independent observers coded the Test of Playfulness. Inter-rater agreement had been measured and disagreements had been solved.
Key results: The ToP scores varied from -2.40 to 2.40 (mean score = 0.25, SD = 1.26). No significant differences in the Playfulness scores were observed comparing the use of classic and robotic toys (mean ToP score_classic = 0.29, SD = 1.32; mean ToP score_robotic = 0.20 SD = 1.23, $p > 0.70$). The differences between the Playfulness scores were also analysed for: a) each child: one child only (male, age = 7.75, with intellectual and physical disabilities) obtained a higher Playfulness score when using classic toys than robotic toys; b) each toy: no significant differences were observed (all $p > 0.05$).
Conclusion: First results showed that robotic toys did not support playfulness more than classic toys. Future analyses will deepen the association between the usability and accessibility of the toys and the severity and characteristics of the disabilities. Moreover, the play partners' competence in supporting play and playfulness will be analysed as well.
Keywords: Play, playfulness, robotic toys, intellectual disabilities.
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Guidelines and Tools on Usability and Accessibility of Toys and Technologies for Play for Children with Disabilities: Review and Proposal from the LUDI Project

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Background: Play is important for each child. Toys, games, apps, robots and other technological products can elicit great play opportunities. Moreover they can create inclusive play and support children with disabilities often challenged among others in playing different play objects. However finding, choosing, evaluating, designing or producing a toy or technology usable for all children can be a struggle. Professionals working with children with disabilities as well as designers and engineers might benefit from guidelines or tools on usability and accessibility of toys and technologies.
Method: Within the LUDI project, COST action TD1309, a scoping review was carried out to answer the following questions (1) which guidelines and tools regarding usability and accessibility of toys and technologies for play for children with disabilities exist? (2) what is their possible use for different stakeholders involved in play for children with disabilities? and (3) what are the strengths and the weaknesses of the guidelines and tools? Four different sources were consulted: LUDI database (stored at: http://ludi.utad.pt/), collected sources of LUDI members, experts in the field of play for children with disabilities, scientific databases and hand search.
Key results: The search yielded 15 sources on usability and accessibility of toys and technologies for play for children with disabilities. An in-depth review with an adapted version of the AGREE II instrument

gained 10 suitable guidelines for designing, producing, choosing or evaluating toys and technologies on usability and accessibility. Five of these had a focus on play. From these ten guidelines four were related to persons with disabilities. The topic of these guidelines was: games/apps (6), toys (1), indoor playthings and environment (1), generic principles (1), all kind of toys and technologies for play (1). Only guidelines with recommendations for a specific stakeholder group with a specific play object (games or toys) were found. Tools such as assessments, checklists were not emerging from this scoping review. No guideline neither a tool about usability and accessibility of a robot for play for children with disabilities emerged.

Conclusion: Based on these results, it was decided to develop a guideline for different stakeholders about usability and accessibility of toys and technologies for play for children with disabilities. The choice for a focus on stakeholders and not on a specific technological product, i.e. robots, was based on limited availability of research data about robots for play for children with disabilities and the wish of stakeholders to address play objects in general. The different guidelines reflect the expertise of LUDI members including their network in pragmatic documents with reflective questions to support the decision making process of the user. In these newly developed guidelines the results from the scoping review were incorporated. A small feasibility study gave an impression about first experiences and opinions of potential users of the guidelines in different European countries.

Keywords: guidelines and tools, usability, accessibility, toys and technologies, children with disabilities.

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Taking Integrated Augmentative Manipulation and Communication Assistive Technologies to Daily Intervention Practice

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Background: Children with motor impairments may have difficulties in manipulating objects impacting their participation in play and academic activities, thus affecting their cognitive development. Lego® Mindstorms® controlled through augmentative and alternative communication (AAC) devices has been used to build integrated augmentative manipulation and communication assistive technologies (IAMCATs). IAMCATs allow children to communicate while using the robotic tool for indirect manipulation, building on their expertise with the AAC device and access method. They also provide a means for children to demonstrate their abilities, opening a window into children's skills. IAMCATs have been used to support: a) participation in free and directed play; b) participation in mathematics, language, and science & social studies academic activities; c) training assistive technology indirect access methods (scanning). This paper reports the first steps in taking IAMCATs to daily intervention practice at the Calouste Gulbenkian Rehabilitation Center for Cerebral Palsy (CRPCCG) in Lisbon, Portugal. This center accumulates more than 45 years of experience providing rehabilitation services to children with disabilities, combining clinical practice with clinical research.

Method: In order to define the requisites of an IAMCAT to be used in daily intervention with children with neuromotor impairments, a Research Assistant spent one month at the CRPCCG. The IAMCAT developed in a previous project was used to exemplify what may be the features of such a system. Through informal conversations with the center clinicians, possible uses for the system were identified. Eight children with neuromotor impairments aged 3–9 years trialed the IAMCAT in semi-structured play activities in three levels of difficulty.

Key results: Clinicians at CRPCCG identified several possible interventions in which the IAMCAT could be useful, including play, development of visual-spatial perception, anticipation and planning skills, increase attention span, cause-and-effect and turn taking training. Challenges mentioned include the need for having a) easy-to-follow operation instructions, b) a playful training protocol for children, c) different operation scenarios, and d) intervention protocols for the different intervention goals. Children were curious about the IAMCAT and willing to try it. Due to their ages and the lack of training on the use of the IAMCAT, participants

were only able to perform the simplest tasks. Five of them used trial-and-error strategies to perform level 1 tasks (e.g., make the robot move). Three were able to drive the robot to a given location without obstacles (level 2 task). None was able to accomplish a level 3 task (e.g., avoiding obstacles). Nevertheless, observation of children using the IAMCAT confirmed the potential of the tool.

Conclusion: An IAMCAT can be a useful tool in a rehabilitation center to help achieving different intervention goals. Challenges identified may be addressed by an appropriate translation of research results into protocols that can be implemented in day-to-day interventions. Future work includes the deployment of a website containing detailed but easy-to-use operation instructions and intervention protocols, and then systematically follow their implementation in daily interventions at the CRPCCG. Properly documenting the interventions will allow for more robust conclusions on the use of IAMCATs in daily intervention practice.

Keywords: Integrated augmentative manipulation and communication assistive technologies, robotic assistive technologies, neuromotor impairments.

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Playing with ZORA – Robot supported therapy and education for children with severe physical disabilities

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Background: Play is of crucial importance for the development of a child. Especially children with severe physical disabilities may experience difficulties in play and they often need assistance while playing. Play activities may be partially or entirely impossible for these children e.g. manipulation toys, or accessing playgrounds. New developments in the field of technology and ICT create new opportunities which may improve the play possibilities for these children. This paper presents the results of a study using robot ZORA for children with severe physical disabilities in therapy and special education. The contribution of ZORA to the achievement of therapeutic and educational goals and the roles professionals attributed to ZORA were examined.

Method: A mixed methods approach was used and was conducted among children with severe physical disabilities, in multiple rehabilitation and special education environments. Over a period of six weeks, children played and practiced with ZORA six times in either individual or group sessions. Professionals (therapists and teachers) attended a ZORA training session, decided for which goals they would like to apply ZORA and designed specific scenarios with the researcher and IT expert. Previous research indicated that ZORA can contribute to goals within the domains of movement skills, communication skills and cognitive skills, therefore professionals selected goals within these domains. The Individually Prioritized Problem Assessment (IPPA) was used to assess to what extent the individual goals were reached according to the professional. Furthermore, playfulness and the children's experience of the sessions were assessed using a visual analogue playfulness scale (range 0–10) and smileys (like, neutral or dislike). Video-stimulated recall interviews were used to gain insight into the different roles of the robot during the sessions. The IPPA and playfulness data was analyzed using descriptive statistics. The interviews were transcribed, labelled and coded.

Key results: In total 33 children (11 girls, 22 boys) with physical disability participated in this study. The chronological age of the children was 2 to 21 years old, and their developmental age was between 2 and 8 years old. Twelve professionals took part by preparing and leading the sessions and taking part in the interviews. A significant difference was found between IPPA before and after the intervention sessions ($p = 0.001$), which indicates a positive contribution of the ZORA-based intervention sessions to the achievement of goals. Looking at specific domains the largest contributions were found on the domains of movement communication skills. The average score of playfulness of all sessions taken together was 7.5, indicating that ZORA elicits play. Overall, the children liked playing with ZORA, since they chose the 'like' smiley in 93% of the sessions. The most suitable roles of ZORA according to the professionals are the roles of motivator, rewarder and instructor.

Conclusion: This study indicated that robot ZORA can be an effective tool to be used in rehabilitation and special education to reach therapeutic and educational goals. ZORA in particular, and robots in general, may offer the next generation of play for children with severe physical disabilities.

Keywords: Robot, children, physical disabilities, play.
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Special Thematic Session 11
Innovative Approaches in Building Inclusive Educational Environments with Technology

Building inclusive education environments in the digital era entails numerous opportunities as well as many challenges. Additional aspects of integrating (assistive) technology in education are added towards the goals of digital inclusion that need careful management and monitoring. Digital literacy for all learners becomes a substantial aspect of the use of technology in order to create inclusive learning communities, as this is also defined by the UN Convention for the Rights of People with Disabilities. Recent research evidence, such as the work of the ENTELIS network, yielded a number of considerations but also highlighted a number of opportunities for overcoming barriers and reducing the digital divide. The discussion around digital divide, especially for learners with disabilities, does not solely concentrate on the technological dimensions and lack of access to technology resources, but it is aligned with the current conceptualization of inclusive education. Self-assessment, action research and reflective practice are becoming renowned approaches for defining goals and monitoring progress towards digital inclusive education. This special theme aims to explore some examples of such approaches when using technology for inclusion and to discuss considerations and opportunities involved.
Chairs: *Katerina Mavrou and Silvio Pagliara*

"Nothing about Us without Us": Next Level

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Background: Education is a prominent facilitator of inclusion amongst up-to-date Information and Communication Technologies, Assistive Technologies and (e)Accessibility. While there is a most complete corpus of initiatives, guidelines and regulations in Europe dealing with delivering education to children with disabilities in elementary and secondary education (irrespective of the further process and if this education takes place in an inclusive or special educational context), the number of initiatives, measures and regulations get scarce when it comes to Higher Education and further diminishes at doctorate level. This leads to a lack of peers (people with severe disabilities) in further (university) research, project work, teaching and last but not least also policy making. It applies to all fields of university research (including disability studies and rehabilitation). What adds quality to state of the art in modern management – implementing diversity – is lost at university.
Method: In preparing for this endeavor and in order to evaluate the situation and possibilities in Austria, we followed a four-fold study path: (a) Preparatory desktop research on legal regulations and numbers at European level, (b) expert interviews with students and researchers (with and without disabilities) asking what keeps candidates from as well as in following a doctorate in Austria, (c) observations from a similar action called PROMI in Germany and (d) setting up a field trial framework in Austria to be able to conduct an accompanying study/work in progress activity for graduates with disabilities in doctorate studies while researching the main facilitators and barriers as well as get a sound understanding on numbers and target group.
Key results: Studies show that the number of masters exiting university is about 8000 per year, about 800 extra finish with a doctorate. An estimated ratio of 20% (people with any form and grade of disability amongst the Austrian population) would mean an output of about 1600 graduated with disability and consequently 160 doctors with disabilities, numbers that are certainly not reached. But also if one only takes 10% of these mere estimations (as in Austria, data on "disability" and health require particular protection and are not part of formal population census), the resulting number – following support and counselling services for students with disabilities at all Austrian Universities – would be overestimated – leading to similar values and findings in other European countries that have a similar "tertiary quota" amongst their labor force.
Conclusion: In parallel to the Austrian field trial – installing and staffing (altogether 6) fully accessible and fully funded 4 year positions for doctoral students with severe disabilities at all major Austrian universities – we will present necessary research to be conducted these next 4 years – compiling a significantly reliable corpus of data/numbers, researching facilitating and detrimental factors (besides financial and accessibility issues – for transferable structures preparing this next level of inclusion: People with Disabili-

ties following a stable research and career path at university, enriching quality of life and research (not only in disability related studies) and bringing high impact research and development to the next, necessary level.
Keywords: Research, Disability, University, Doctorate.
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Accessibility Evaluation of Computer Based Tests
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Background: The accommodations in exams (e.g. scribe, compensatory time and magnification) are widely used for many years to accommodate visually impaired persons (VIPs). Nowadays, most of the exams are conducted using computers and web-based technologies referred to as Computer-based tests (CBTs). These CBTs play an important role in the professional advancement of any individual, starting from university admissions, courses evaluation and grading, to the recruitment in almost all software companies. Barriers in accessing certain components of the CBTs limit the utilization of these technologies for VIPs. In this work, we evaluated the availability and effectiveness of common accommodations in CBTs. To the best of our knowledge, this is the first attempt to systematically study the effectiveness of these accommodations.
Method: We used a questionnaire to evaluate the accessibility barriers in the CBTs. 24 participants responded until January 15$^{\text{th}}$, 2019. These were VIPs from IIT Kanpur, IIT Delhi and registered participants at the assistive technologies conference, Empower-2018. We analyzed the accessibility of CBT interfaces, the effectiveness of accommodations provided to VIPs, the comparison between available and expected accommodations, and finally the preferences of VIPs for various accommodations. Using this data, we have proposed recommendations to adopt more technology-based accommodations in CBTs.
Key results: Every VIP is unique and requires appropriate accommodations in CBTs to overcome the accessibility barriers. The data obtained from the survey reveals that 6.9% (2/29) of VIPs preferred scribe over other accommodations. 27.3% (6/22) of those who used a scribe reported enhancement in their performance, rest of them reported either drop or no impact. Hence assistive technologies such as screen readers along with accessible formats of contents should be used to accommodate VIPs. Compensatory time was useful for almost everyone regardless of the extent of disability. The usefulness of magnification was reported by only 25% (3/12) of participants with 90% or more disability, while others reported significant improvement in reading speed. We analyzed the availability and expectation of various accommodations in CBTs and found that scribe and compensatory time were available while accommodations such as magnification of text, screen reader, option for choosing colour contrast and bigger monitor setup were rarely available during CBTs, although data reveals that 30%–50% VIPs preferred these accommodations.
Conclusion: The results about the effectiveness and preference of using a scribe in CBTs are contrary to the beliefs. Our observations identified the needs for technology-based accommodations over scribe to a diverse group of VIPs. We showed that the extent of residual vision in VIPs is one of the major factor in determining the type of preferred accommodations. CBT interfaces can be personalized to fulfil the needs of VIPs with the use of assistive technologies. In the future, we would like to extend our study for a greater number of people, other disabilities, different types of CBTs and for more geographic locations. Moreover, similar studies can be conducted for the accessibility of online programming competitions.
Keywords: Visually Impaired Persons (VIPs), Accommodation, Computer Based Tests (CBTs).
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LernBAR [Learning based on Augmented Reality] – An inclusive Training Concept for Home Economics
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Background: LernBAR is a research and development project for vocational training using digital technology as a core element. The project examines augmented reality (AR) based vocational learning for people with cognitive impairments in home economics. Digital media can facilitate vocational life and has great potential for challenged learners. One innovative digital learning method is AR-based learning. AR supplies additional information e.g. videos/audio which is presented with

a mobile device (glasses/tablet) in the real environment complementing the view of reality. At the workplace the system can recognize objects or markers to call up environment-related digital artefacts. Learners are supported individually through the learning process, providing motivation, allowing repetitions, etc. AR specifically relates the learning experience to the actual workplace in reality (Fehling 2017, 127ff, 129f). Due to demographic and social development in Germany the importance of home economics increases, however training figures decreased over the years (BiBB Datenreport 2016, 35). A modernization could enhance the appeal and future sustainability of the vocational training (Fehling 2017, 126). The project focuses on realizing AR-based learning and establishing further learning opportunities via an e-learning platform. Therefore, a new curriculum is being developed and tested. Since home economic services constitute a large part of vocational training for people with cognitive impairments the project examines the usability of AR for this target group. Therefore, three institutions that offer vocational training for the target group are supporting the project as partners.

Method: The project starts with analyses of literature and interviews of partners. The curricula for vocational training in home economics are adjusted to include digital learning (like AR). Therefore, the partners' curricula are analysed and merged using document analyses (Mayring 2007, 31). Based on the outcomes of the interviews the learning scenarios are created. Work process analyses are conducted with the partners, including observations, control videos, expert interviews and interviews with trainees (Spöttl and Windelband 2006, 139). The material is used to create learning content. On the technical side an application for displaying the learning content on glasses and tablets is developed and an e-learning platform is adapted for the project. The developed contents are tested with the target group using observations and surveys on acceptance/usability. The results allow target group specific adjustments. Various offers like workshops, guides/manuals, etc. allow the implementation. The project has a duration from June 2018 to May 2021 therefore not all steps have been completed.

Key results: Desired results in practice include 30 learning scenarios for AR and the e-learning platform. Goals in research are to gain practical research data on learning and teaching with digital media/AR and insights on acceptance and usability for people with disabilities.

Conclusion: AR technology is expected to have great impact on future work life (Peddie 2017, 27). The project explores the suitability of AR-based vocational learning for people with cognitive impairments in home economics.

Acknowledgement: The project LernBAR is funded by the German Federal Ministry of Education and Research under the funding code 01PE18004B. Responsibility for the content of this publication lies with the author.

Keywords: augmented reality, vocational training, cognitive impairment, (education), (home economics).
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Mainstream traditional or robotic toys: Which of them better supports playfulness in children with disabilities?

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Background: Play is the main drive for development and is fundamental for physical, cognitive and social development (Piaget, 1945/1972; Vygotsky, 1976). Playfulness is the child's 'disposition to play' (Barnett, 1991). Playfulness can allow to discriminate between play for the sake of play and 'play-like' activities (Visalberghi, 1958), which occur when play is used as a means to achieve 'other' purposes, such as learning or skill improvements.

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Conclusion: First results showed that robotic toys did not support playfulness more than classic toys. Future analyses will deepen the association between the usability and accessibility of the toys and the severity and characteristics of the disabilities. Moreover, the play partners' competence in supporting play and playfulness will be analysed as well.
Keywords: Play, playfulness, robotic toys, intellectual disabilities.
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Meta-analysis on the Impact of Augmented Reality on the Learning Gains of Students with Special Needs

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Background: Augmented Reality (AR) has become an important technology to support learning processes. Many literature reviews have shown the trends, advantages, opportunities, and challenges of this technology in educational settings. These reviews report that one of the most important challenges of AR in education is the limited number of AR applications that consider the special needs of students. However, although there is a claim for the inclusion of accessibility characteristics to address the special needs of users, no study has been conducted to identify the impact of AR on the learning gains of students with special needs. That is, no data show that using this technology benefits the learning process of students with special needs or under what conditions AR should be used to complement their education. Many studies have shown that AR technologies offer unique advantages that enrich the learning environment, advantages that could not be obtained without the help of technology. Consequently, we pose that these unique characteristics of AR have a large impact on special needs education. With the above background, this study proposes to identify the effect size of AR on the learning gains of students with special needs. Additionally, the study analyzes the influence of moderating variables related to the design of the intervention such as learning method, learning environment, and intervention duration
Method: We conducted a meta-analysis to identify the impact of AR on the learning gains of students with special needs. The meta-analysis included 12 empirical studies (N = 270) published between 2010 and 2018 in scientific journals and conference proceedings. In this study, students with special needs refer to students who have some type of disability. Accordingly, we considered four types of disabilities, namely, vision impairment, deaf or hard of hearing, intellectual disabilities, and physical disabilities. The moderating analysis seeks to identify under what conditions students with special needs can obtain the best of this technology for their education.
Key results: The overall effect size of AR on the learning gains of students with special needs was found to be $d = 0.75$, $p < 0.001$. Regarding the moderating variables, the constructivist learning method was found to be the most beneficial for students with special needs ($d = 0.81$, $p < 0.001$). Likewise, AR applications seem to be more effective when interventions are carried out in informal settings outside the classroom ($d = 0.79$, $p < 0.001$). Finally, the results indicate that longitudinal studies were more positive ($d = 0.78$, $p < 0.001$) than cross-sectional studies.
Conclusion: The results indicate that AR has a positive impact on the learning gains of students with spe-

cial needs. The effect size was found to be large for all the subcategories according to Cohen's classification. However, despite the apparent multiple benefits, the use of AR in special needs education is still too limited. Therefore, stakeholders have great opportunities to develop new and better systems that include all type learners.

Keywords: Augmented Reality, Meta-analysis, Special needs education.

Acknowledgements: This work has been partially supported by the project "RISE Women with disabilities In Social Engagement (RISEWISE)" under the Horizon 2020 programme (Grant Agreement: 690874).

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Augmenting Reading through Technology: The Living Book Project

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Background: Reading literacy is nowadays a primary skill allowing citizens to 'be' and live in a complex world. The Living Book project aims to address the under-achievement of students in reading and literacy, by developing an innovative approach and related resources with the use of technology to increase students' motivation. The wide range of disabilities and the educational services learners have access to, impact differently on individuals' literacy skills and engagement to literacy activities. Thus, learners with disabilities are considered among the most high-risk groups for low literacy skills. This contribution aims to discuss the theoretical aspects of the Living Book project and the development of the corresponding conceptual framework for teachers' education to support learners with disabilities.

Method: The project aimed at designing and implementing an educators' and other professionals' development program grounded on various interrelated bodies of research, including inclusive education and digital inclusion. The programme was pilot tested during Spring-Fall 2018 with a series of hands-on professional development seminars. To evaluate the applicability and success of the training modules, participants (primary education teachers, special education teachers and librarians) will subsequently undertake a teaching experiment during Fall 2018 – Spring 2019, where they activate Living Book learning paths. Presentation of evaluation and impact findings are out of the scope of this contribution. However, for testing and validating the conceptual framework, teachers' and learners' experiences will be mapped across the framework's blocks.

Key results: In this paper key results refer to the development of a conceptual framework. With respect to (digital) inclusive education the project builds upon the following theoretical perspectives: (i) Augmented reality and innovative technologies; (ii) Universal Design for Learning (iii) the SAMR model for technology integration in Education; (iv) Taxonomies of Assistive Technology and E-Inclusion. For targeting learners with disabilities, the different approaches developed in the project are based on a framework that connects the SAMR model to the UDL principles and Abbot's taxonomy of Assistive Technology for e-inclusion. Often the use of assistive technology in literacy development remains at the level of physical or content/information accessibility. In Living Book, augmented reading for disabled learners is framed in the (re)definition of inclusive education in the digital era. (Assistive) Technology integration is expected to provide accessible but also engaging literacy experiences. Hence innovative technology integration (e.g. the use of AR) elevates from Substitution and Augmentation to Modification and Redefinition of literacy activities. Substitution and Augmentation reflect the UDL representation and action & expression principles, which are aligned to Abbot's Technology for 'Practice' and 'Assist' learning. However, 'Enabling' learning with assistive technology indicates Engagement and thus, calls for Modification and Redefinition of literacy activities. Mapping participants' experiences to the conceptual framework is expected to yield discussions upon the desired shift in the learning paradigm for increasing engagement.

Conclusion: The use of assistive technology in education can go beyond physical access and accessibility. In a digital era, assistive technology is a means to modify and redefine the learning environment for creating digital inclusion opportunities and cultures in schools by problematizing the added value of technology integration in disabled learners' engagement and acknowledging the multi-faced interaction between person, technology and environment.

Keywords: Augmented reading, UDL, SAMR, Augmented reality, Digital inclusion.

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Flipped Classroom for All in Primary Education: Using Technology for Differentiation and Inclusion

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Background: In this article, the results of a multicase study will be presented which aimed to address an important gap in current literature concerning instructional practices using a Flipped Classroom (FC) model, implemented in line with universal design principles. There has been a limited research focus on the implementation of the FC model within the primary education context despite its potential benefits for differentiation and inclusion, especially through the use of technology.
Method: The study is a collaborative action research project, during which the researcher, in collaboration with five primary school teacher participants, explored the effective ways of universal implementation of the FC model in primary school settings in Cyprus. To achieve the aim, this study first developed a pedagogical framework of (Inquiry Based) IB-FC which consists of universal design principles of using the FC model for IBL (Inquiry-Based Learning) at a primary education level. The universal design principles here include the specific pedagogical strategies to motivate and improve students' learning applicable for all primary school subjects, through differentiation and inclusion. The model was implemented for a school year in five different primary schools in Cyprus, engaging 77 students (lower and upper primary). The digital literacy competency of the participant students had been addressed by preparing flips in diverse formats, e.g. video, presentations, games, online readings, webQuests etc. In addition, the flips and the inquiry-based activities in class were uploaded and administered through a Moodle platform (http://protyposxoleio.com), specifically designed for the research. Therefore, all students could access content through any connected device with no compatibility issues. Qualitative data has been selected through classroom investigations and student interviews and has been analysed using NVivo11. The final themes arising were grouped into students' experiences and perceptions.
Key results: Students' experiences and perceptions on the IB-FC implementation have been used to revise the initial instructional tools given to the teachers for developing their lesson designs (e.g. the IB-FC Differentiation tool). This in turn lead to the extraction of seven final universal design principals which could enhance differentiation and inclusion through FC learning, recognizing the critical role of technology in achieving this. These include: *structure and flexibility, simplicity and accessibility, interconnectivity and community, differentiation and personalization, development and progression, motivation and engagement and assessment and evaluation*.
Conclusion: The final IB-FC framework proposed in the findings of this multiple-case study illustrates how the seven universal design principles for FC implementation are connected to the ten instructional IB-FC tools developed: *In-class, orchestration routines, engagement, differentiation, technology, in-flip, community, IB-FC skills, assessment and evaluation, flips and Bring Your Own Device.* These tools mainly highlight the role of technology in freeing up classroom time for more IBL inclusive activities, by enhancing pre-class understanding within the individual learning space through the provision of flips in diverse formats. Hence, the contribution of this study within the AT field focuses on these principles and instructional tools as an attempt to guide FC implementation which addresses the needs of all students, despite their learning type, ability and skills.
Keywords: flipped-learning, differentiation, inclusion, universal design principles.
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Project E-IDEAS: Empowerment of Youth with Intellectual Disabilities Through an Individualized Transition Program Including AT for Acquiring Employment Skills

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Background: The project E-IDEAS is an on-going research funded in 2017 by Marie-Curie Action program and the charity RESPECT. It is implemented at the National University of Ireland in Galway and it is aimed to develop a transition program for allowing persons with Intellectual Disability (ID) to find paid job.
The rational is represented by the high levels of unemployment and underemployment of youths with ID in Ireland.

Considering that youths with ID have less favorable transition outcomes than youths in the general population and that employment opportunities are even less promising the initial question was: *How to bridge the "gap" between what youths with ID "can do" and what they really "are doing" in employment sector?*
Method: The project E-IDEAS uses a mixed method that incorporates participatory research approach with qualitative research methods.
It addresses the current educational and career preparation context for youths with ID in Ireland through a transition program composed by three main activities:

1. Delivery of an Employment Preparation Curriculum (EPCv), developed using a person-centered approach.
2. Provision of an Individualized Internship, supported by job coaches of local organization (EmployAbility Galway) that provides real-life work experience.
3. Use of assistive technology (AT), including tablets and app AVAIL a mobile solution based upon the principles of ABA (Applied Behavior Analysis) enabling learners to develop life skills.

Five persons aged between 20–25 with mild to moderate ID (IQ 50–70) were recruited by a local organization (Ability West). The transition program started in January 2019, it lasts for 4 months and it will be extended until summer 2019.
Key results: The analysis of results is currently ongoing. A questionnaire on the quality of life (San Martin's scale) has been administered to participants at the beginning of the transition program and it will be compared with the data collected at the end of the process. Initial findings already emerged are:

- The provision of EPCv concurrently delivered with the internship reinforces learning and provide a safe environment where to discuss and ask questions.
- The adoption of AT leads to positive results that helps to achieve a long-lasting acquisition of skills to perform job-related tasks although it requires a continuous support.
- A strong partnership between different local stakeholders guarantees an effective transition towards job experiences.

Conclusion: The main practical implication of the research is that through a specific curriculum delivered concurrently with an individualized internship realized in real-work settings, it is possible to empower persons with ID for acquiring employment skills. Also, the adoption of AT reinforces what learned in classroom as well as tasks' execution during the internship. In this view, the research's results affect the AT field providing the opportunity to develop a technology learning environment that facilitates acquisition and exploration of job-related skills. Future perspective in terms of short and long-term impacts are:

- Improve employability for youth with ID.
- Help service providers in Ireland expand their community services.
- Definition of practical actions aimed at impacting on mind-set and common beliefs with respect to disability and employment.

Keywords: Empowerment, Intellectual Disabilities, Individualized Transition Program, Assistive Technology, Employment Skills
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Special Thematic Session 12
Developing Assistive Technology Together with End-users, Business, Healthcare and Knowledge Institutes – Challenges and Benefits

This thematic session focusses on the potential of living labs in supporting companies in further developing assistive technology in order to develop an effective, usable and sustainable solution of the real problems in health care. What is the benefit o f cooperation between companies with AT, knowledge institutes and health care organizations? What is the contribution of research institutes like universities and applied knowledge centers involved? And how do health care institutions themselves organize in order to improve the match between assistive technology developed and needs of in health care.
Chair: *Paulette Wauben-Penris*

Designing End-user Adaptable Interactive Rehabilitation Technology

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Background: Technology supported rehabilitation training after stroke has been a topic of interest for many years. While numerous solutions have been developed and evaluated, most of these solutions pertain to a limited set of exercises, pathologies and use cases.

Providing personalized solutions, and adapting to new or changing patient demands, is difficult for such technologies, since most of their functionality has been defined during a design phase that predates their actual use. This calls for technology that facilitates adaptation and customization to patient needs, without demanding skill and knowledge typically associated with designing or implementing new technology.
Method: In close collaboration with a clinical partner, we developed TagTrainer: an end-user adaptable technology for physical rehabilitation after stroke. In an iterative, user-centered process, therapists were involved in the design and implementation of the technology. TagTrainer consists of multiple interactive surfaces that detect objects outfitted with RFID tags, and provides visual and auditory feedback. The system is connected to a computer on which therapists can modify, expand or create exercises for individual patients. Any object of daily life can be integrated into an exercise, simply by attaching an RFID tag to it. TagTrainer was evaluated in four field studies in rehabilitation clinics for a total of 24 weeks. In all studies, we measured technology acceptance (UTAUT), interviewed therapists on their experiences in using TagTrainer, and analyzed the rehabilitation exercises that were created by the therapists.
Key results: Technology acceptance was moderate over the four studies, remaining relatively stable over the course of each study. Therapists created a total of 37 new exercises for their patients, showing that in principle they are able to adapt TagTrainer to the needs of their patients. However, through the interviews we also encountered several issues pertaining to the feasibility of implementing an end-user adaptable technology such as TagTrainer in a clinical context. Amongst others, the organizational model of clinics does not facilitate therapists in engaging in activities other than patient treatment. Additionally, therapists indicated that important efficiency benefits could be reaped from (partly) reusing existing exercises, but that judging the usefulness of exercises created by colleagues for a particular patient prevented them from doing so. Finally, the therapists voiced concerns about the impossibility to validate the effectiveness of each and every personalized exercise.
Conclusion: While the principle of an end-user adaptable technology for physical rehabilitation after stroke seems promising, deploying the technology in a clinical context has shown that there still are many challenges to be overcome. Furthermore, the studies have shown that even when clinical partners are involved in the development of a technology, non-technical and policy issues might arise upon deployment.
Keywords: End-user adaptable technology, physical rehabilitation, stroke, deployment study.
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'Sharing is Caring': What are the Main Legal and Ethical Challenges to be Looked at when Co-designing Assistive Technologies?

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Background: The way in which assistive technologies (ATs) are ideated and produced today has significantly evolved from the fashion in which they used to be done in the past. Over the recent years, new forms of bottom-up innovation and social collaboration for the co-creation of healthcare solutions have emerged. Such initiatives involve the interaction of a range of stakeholders, including designers, healthcare professionals, makers, fab labs, and end-users who – for different purposes or ideals – put together their efforts and knowledge in order to co-design and reproduce various types of ATs. One notable example of this new paradigm is represented by Careables.org platform – an initiative by the Made4You project. Its aim is to create an online platform to enable stakeholders possessing broad and diverse knowledge to share it for the subsequent co-creation and reproduction of customized healthcare solutions. Examples of ATs created in such a manner include 3D-printable prosthetics hands, wheelchair mounted environment controllers, learning supports, assistive phone cases, open lights for wheelchairs, to mention but a few. While social effects concerning co-designing initiatives clearly appear to be beneficial – especially in cases where a given AT does not exist on the market yet, it is too costly, or it has not been tailored to meet the needs of an individual – the ethical and legal requirements have only been partially addressed in the literature and have rarely been implemented in practice by the aforementioned stakeholders.
Method: Through this contribution we will outline the main legal and ethical requirements to be regarded when a healthcare practitioner, developer or an individual wishes to design, co-create or reproduce an AT through such a bottom-up approach. This contribution stems from a desktop research carried out within the context of the Made4You project by legal researchers of KU Leuven whose main focus was on the EU

primary and secondary legislation dealing with privacy, data protection, intellectual property rights, open source/hardware licensing, and medical devices regulation. Finally, the main ethical principles will be outlined.

Key results: With regard to the legal framework following questions will be addressed: what is the applicable EU legal framework for co-designing ATs and what are the main legal requirements to be considered? The research has shown that as of primarily interest for stakeholders are fundamental human rights (in particular privacy and data protection), intellectual property rights and open source/hardware licensing, liability of ATs co-manufacturers, and qualification of a co-designed AT as a medical device. With regard to the ethical framework the question that has been studied is: what are the major ethical principles to be regarded when co-designing a new AT? Principles such as justice, beneficence, and non-maleficence have been emphasized as the most relevant in such a context.

Conclusion: The findings to be presented through this contribution aim at providing a point of discussion about the legal and ethical aspects for the co-design and co-creation of ATs. The research results are directed towards all stakeholders that may have an interest in undertaking co-designing activities in order to raise awareness of the crucial legal and ethical requirements that should not be overlooked when applying the bottom-up approach for the development of ATs.

Keywords: Intellectual property, open hardware licensing, medical devices.

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Structural Collaboration Between Care Organizations and Universities

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Background: Care technology is regarded as one of the solutions dealing with a growing demand for care. In the Netherlands, care professionals are often contacted by companies marketing their new products. Although long term care organizations are open to new technological developments (e.g. e-health, robots and virtual reality), healthcare professionals dealing with technology implementation in long-term care, face a number of challenges. Firstly, the technology doesn't (always) fit the needs of clients and/or professionals. Secondly, research regarding the added value or feasibility of technological products is scarce; care organizations often lack capabilities and time to evaluate the technology at hand in a proper and concise manner. Lastly, there is lack of structural implementation of care technology within long term care organizations, often resulting in ad-hoc decision making. Seven institutes for long-term care decided to join an initiative started by the Living Lab in Ageing & Long-Term Care (Academische Werkplaats Ouderenzorg Zuid-Limburg, AWO-ZL).

Method: The collaboration named "AWO-ZL Group Care Technology" started in September 2018. Our aim is two-folded:

- Reaching more efficiency for care organizations by:
  - Collaborating in assessing the added value and feasibility of care technology;
  - Sharing experiences and acquired knowledge regarding (test results of) care technology;
  - Involving researchers (supported by bachelor and master students) in life-testing.
- Contributing to the development of care technology products by:
  - Providing feedback to entrepreneurs (on technology in different stages of development) based on their pitches;
  - Organizing and performing life-tests regarding the technological products those entrepreneurs have developed.

Representatives of the seven care organizations, Zuyd University and Maastricht University agreed to meet bimonthly in order to invite technology companies. In these meetings new technologies are discussed even as methods to evaluate them and outcomes of life-tests when available. Each care organization agreed to perform at least one life-test a year, supported by scientific researchers at Zuyd University and Maastricht University. Short interviews were held to capture the experiences of care professionals and entrepreneurs.

Key results: Six meetings have taken place in which 10 companies pitched their technological products; 4 life-tests have been or are planned to be conducted. The first evaluations show positive experiences: care professionals realize they often deal with similar questions: Does the technology work? Do we have (this) need for innovation? Does it fit our patients? Do our

healthcare professionals know how to use the technology at hand? Hence, there's a lot to learn from the experiences and knowledge of other organizations. Entrepreneurs value the positive attitude displayed in the meetings; they feel it is beneficial to meet experts in de field of care technology in order to have thorough discussions. For Zuyd University and Maastricht University the collaboration is a good example of our living lab where practice, research and education intertwine creating a valuable learning environment for all involved (incl. care professionals, researchers and students).

Conclusion: Collaboration between care organizations and universities for evaluating care technology seems beneficial in order to improve implementation of care technology in long-term care organizations.

Keywords: Living Lab, Long-Term Care, Assistive Technology, Technology Implementation.

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Design and Implementation of a Multimodal Wearable System for Functional Assessment in Rehabilitation and Work

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Background: Nowadays, wearable systems offer a not intrusive ecological solution for people monitoring and functional assessment. These platforms represent an ideal tool for evaluating the rehabilitation evolution and job reintegration of people. To control physical and physiological parameters during rehabilitation process, a multi-parametric system is mandatory, but current systems are bulky or not fully integrated. The aim of this project is to develop a modular textile sensing platform fitting different people and job situations.

Method: Co-design mixed with technical analysis is the adopted method. Three design iterations were carried out. In the first step, two Users focus groups participated by patients, caregivers and technologists were carried out for the design of the basic requirements. A dedicated and ad-hoc created, questionnaire web-administered to 40 end-users provided the final definition of the functional requirements of the system. The second step consisted in the technical analysis and design and its validation with a panel of users. Anthropometric analysis and wearability analysis were conducted in parallel with textile materials analysis and technologies selection (for sensing, processing and transmission); according to these outcomes, a preliminary design was developed for aesthetical and comfort assessment only, by simulating hardware shapes and volumes and weight through rapid prototyping techniques. A questionnaire for acceptability and usability based on 5 questions (using Likert scale) confirmed the design.

Key results: According to the results of user research, the main system requirements are: on one side, the need to have a modular wearable system, which guarantees high levels of comfort in terms of breathability, freedom of movement and wearability; on the other side, the system has to guarantee an accurate and dedicated monitoring of the specific rehabilitation activity. In particular, the co-design process highlighted that all users are firstly interested in evaluating the global motor function or even of specific body segments, with comparison of data from the contralateral body districts. Physiological parameters as single-lead electrocardiogram, breathing rate and depth and muscular activity, are relevant in subjects with specific cardiovascular pathologies, e.g. post- strokes, when also a total body motor assessment could be useful to be achieved. According to these outcomes, the wearable system in its full configuration is being developed through the implementation of 13 inertial sensors placed onto the body segments in a network which is integrated with the sensing platform composed of conductive fabric electrodes and a dedicated device for ECG, heart rate frequency and respiratory activity (and also EMG in future configuration).

Conclusion: The Multimodal Wearable system is designed to support monitoring of people during rehabilitation and job reintegration in an ecological setting and in a truly integrated physio-physical approach. The complete development and validation are still ongoing but, the promising results about system accuracy in real situations open new perspective for application of the system in work related pathology prevention and even in sport performance assessment.

Keywords: Wearable System, Multimodal monitoring, Co-Design, Ergonomics, Rehabilitation.

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Making Black Swans Free as a Bird: Freedom, Safety and Courage in Psychogeriatric Care

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Background: Living Labs are public private partnerships that aim to bring innovation closer to practice and, in this study, make innovations more meaningful for healthcare practice. This Living Lab project was conducted in a closed psychogeriatric unit in a healthcare organization in the Netherlands. The facility exists of units with three floors for six psychogeriatric clients on top of each other, which limits the space for clients to move around freely. Dementia patients sometimes have the urge to walk and become restless if free movement is not allowed. This restlessness negatively influences the wellbeing of themselves and the other residents. This project aims to explore possibilities to increase freedom for restless psychogeriatric residents, given the physical constraints of the facility and its location.
Method: The project consisted of two phases. The first phase was an in-depth exploration of the problem without focusing on possible (technological) solutions: interviews ($n = 29$) were conducted with various staff members, and four staff members were shadowed during both day and night shifts. Maximum variation sampling was used to ensure the inclusion of perspectives and experiences of all relevant stakeholders concerning the facility. The data were analyzed using open coding to create a list of themes that were used for the second phase. Secondly, the project group, consisting of researchers and employees of the organization, reflected on the central themes in three sessions following the method of frame innovation to formulate innovative solutions.
Key results: Major emerging themes were freedom versus safety, risk staking, lack of contact with colleagues, high work load and time constraints. Staff reported difficulties moving between the unit floors, and that unrest amongst residents negatively influences their ability to deliver person-centered care. Courage, the willingness to try new possibilities without knowing what the possible outcomes and consequences are, emerged as a necessity to deal with the problems of the facility. Whilst deliberating courage, the insight emerged that only a handful of known residents ('black swans') become restless when their freedom was restricted. If those individuals could be temporarily moved to a different location in the facility, which has a circular hallway, disturbances for all psychogeriatric residents may be avoided. This solution emerged without focusing on technology as a starting point but, according to the participants, it will create a context wherein the use assistive technology has a larger chance of success.
Conclusion: Even though this project did not take assistive technologies as a starting point, the findings of the project are relevant for innovators in technology. All participants came to agree that simply implementing new technologies would not have addressed the problem of the facility. Due to the participatory nature of the research a truly innovative solution was found which, additionally, may increase the chances of success for assistive technologies in reducing restlessness for the residents. From a socio-technical perspective this makes sense: healthcare contexts are systems in which people and technologies are closely interrelated. Only if social and technological innovation go hand in hand, chances of success can be significantly increased.
Keywords: psychogeriatric care, participatory research, socio-technical perspective.
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Stay@home with Dementia: Companies, Healthcare, and Knowledge Institutions Challenged for User-centered Design

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Background: Assisted technology (AT) can support the growing number of patients with dementia and their caregivers in daily life, to improve independence and safety. A mismatch between AT and the needs of persons with dementia might explain the limited use of AT. Pro-active involvement of clients and (informal) caregivers(s) in the design and implementation of AT will maximize implementation and the likelihood of technology acceptance. In this project, AT for patients with dementia were designed based on clients' and

caregivers' needs by bringing companies, healthcare- and knowledge institutions together. The aim of this abstract is to address the design process and experienced difficulties.

Method: Three teams consisting of 5 companies and 7 healthcare institutions were created to design AT. The knowledge institutions coordinated the collaboration. An iterative user-centered design approach was used in which the double diamond model was applied. Firstly, a needs assessment [*Jorina Reekmans, Ryanne Lemmens, Steffi Rijs, Annemie Spooren. Stay@home with dementia: from needs assessment to assistive technology, this volume*] resulted the top-10 problem activities and their barriers which were translated into functional requirements (= discover phase). Secondly, in the define phase, the needs and requirements relevant for the AT being developed were defined. Next, prototypes were developed during an iterative process by companies with input of healthcare professionals, repeatedly checked for the functional requirements and tested multiple times with (informal) caregivers (= develop phase). In the near future, prototypes will be tested with clients. At the end, an AT adapted to the needs of clients will be delivered. Feedback on the process was gathered in an iterative way by observation and informal interviews. At the end, teams were interviewed about their experiences.

Key results: A co-creation session was organized, including different methods encouraging user-centered design, to develop conceptual designs of AT. Based on the problem activities 'using appliances' and 'disorientation', 3 prototypes were developed: 1) a simple and adaptable TV remote with possibilities to link with a relax chair; 2) an AT to stimulate day structure, making use of home automation and video messages for clients; 3) a digital buddy in which informal caregivers receive feedback about the actions of the client. Adaptations were made during the iterative user-centered process based on feedback received during tests with (informal) caregivers. In the first iteration the team members were uncertain about their role and there were some difficulties with communication and collaboration. However, at the end, all stakeholders indicated the added value of the complementary expertise and collaboration. Companies and healthcare institutions indicated they were not used to think out of the box with a focus on the problems and barriers. Knowledge institutions experienced difficulties regarding how to translate user needs into technical requirements and some practical problems (i.e. bringing together the team, recruiting clients to test the prototypes). Results of the final interviews are ongoing.

Conclusion: This study gives an overview an iterative used centered design process for AT for clients with dementia living at home. The conclusive enrichment of the process explains the added value of intensive interdisciplinary collaboration between different stakeholders. However, during this process, difficulties regarding collaboration and practical issues had to be overtaken.

Keywords: assistive technology, dementia, user-centered design, collaboration between companies healthcare organisations knowledge institutions.

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ARTHE: Development of an Upper Limb Active Smart weaRable Orthosis for Stroke THErapy

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Background: Recovering from stroke is a long and intensive process for both patient and therapist. Since the rehabilitation process is limited in time, focus is primarily on regaining lower limb functionality. Non-functional upper limbs are consequently found in 30%–66% of stroke patients, and only 5%–20% show complete recovery. To stimulate the brain motor (re)learning process, therapy should include active participation during repetitive, task-specific and motivational exercises. In this context, the use of assistive robotic devices, complementary to conventional therapy, contributes to enhanced upper limb motor recovery. This abstract presents the development of an upper limb exoskeleton "ARTHE" that enables patients to enhance their exercise routine.

Method: An exoskeleton, assisting stroke patients during intended flexion and extension elbow movements, was developed based on field observation, literature review and co-creation sessions with both therapists and patients. The device uses EMG sensors (biceps and triceps) and a load cell (integrated in the distal part of the exoskeleton) to detect the user's movement intention. Based on these signals the actuation unit provides motor assistance according to exercise and patient specific requirements. An actuation unit capable of delivering 24 Nm continuous torque was selected. To keep the elbow brace lightweight and comfortable, the proposed prototype transfers torque through a Bowden cable system, so the actuator module can be placed on a more stable surface or region (e.g. hip or table). This pro-

totype was tested on 10 healthy subjects and 9 stroke patients, performing therapeutic exercises in a clinical setting (two 30-minute sessions with 1-week interval). Healthy subjects, patients and their therapists ($n = 2$) that participated in the study answered a questionnaire (based on the D-QUEST instrument) related to ease of use, quality of movement and qualitative improvements. Additionally, the interaction forces between therapist and patient were measured during conventional therapy sessions ($n = 8$) to define the minimal necessary motor torque to be applied by the actuation unit.

Key results: All 9 stroke patients reported a desire to practice more with the ARTHE device, while 8 out of 9 found that ARTHE improved their impaired upper limb movement quality. General concerns were the size of the device and usability in a home environment. The original anticipated continuous torque of 24 Nm was found to be too high for use in a therapeutic setting. The measurement of the interaction forces between therapist and stroke patients revealed that an actuation unit with a continuous torque range of 4–5 Nm and a peak torque of 16 Nm is sufficient, reducing the unit significantly in both size and weight. The force sensor proved to be a more reliable sensor for the stroke patient population. It also increases the user-friendliness by eliminating the need for specific sensor placement.

Conclusion: A prototype of an upper limb robotic device was developed. It received positive reactions from patients that tested the device, since they perceived an improvement in their movement quality. However, the device still needs to be downscaled and usability should be further improved. As input signal, force proved to be more user-friendly compared to EMG.

Keywords: Exoskeleton, Upper Limb, Elbow, Stroke, Rehabilitation.

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Combining Forces in Further Developing an Innovation for Incontinence Care

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Background: In the Netherlands 750.000 people have to cope with the consequences of urine incontinence. High expenses of 149 million on a yearly basis are partly due to the fact that often material is changed before saturation levels are reached. On the other hand material is regularly changed late resulting in discomfort for clients and increased care tasks for staff due to changing bed sheets and clothes and washing clients. The IncoSense Smart is an innovation developed by IncoSense bv that aims to contribute to solving inefficiencies and discomfort in incontinent clients. The tool consists of a sensor, a wearable that measures the saturation level of incontinence material, a notification system and a management dashboard. Aim of this study was to assess the impact of the IncoSense Smart at the level of the client, care, and organization in a real life setting.

Method: The study was conducted in a somatic and a psychogeriatric intramural elderly care facility in the Netherlands. Phase 1: the current state of the art and needs with respect to incontinence care were investigated in one focus group session and two individual semi-structured interviews with staff. Phase 2: technical validation within one of the participating care facilities of the IncoSense Smart and investigation its impact. Technical validation was done in a one week test period. The impact of the IncoSense Smart was assessed among 10 somatic, 10 psychogeriatric patients and their caregivers. Data on saturation of the material were collected in week 0, 1, 4 and 10. A focus group with staff and individual interviews with clients completed the study. Outcome measures were: client and staff experiences, saturation of incontinence material when changed, accuracy changes (too early, late, on time), extent to which clients wear material of appropriate size, amount of incontinence material use.

Key results: Seventeen clients completed the study. Average age of clients was 82 years (range: 67–96). People had been living in the care facility for on average for 33 months (range 2–121). Practically, it was not always to possible to detect saturation levels of incontinence material as clients took off the sensors, sensors were thrown away with the material itself by staff, notifications were not sent or received to phones of staff. 446 pieces of incontinence material were weighted in the study period, which contained on average 358 ml of urine. The average saturation level was 40%.

Conclusion: Testing in a real life setting gives essential information for the (further) development of the Incosense Smart. Not every incontinent client in a care facility will benefit equally from the IncoSense Smart, so selection of the appropriate target group requires attention when implementing the system. Size of material used is often too large, an additional advantage of the IncoSense Smart appeared that it makes staff aware

of the need for using the appropriate sizes and applying material correctly. Adaptations were done to the design of the IncoSense Smart in the meantime and the device has been tested in a care facility in Belgium.
Keywords: Incontinence, Elderly Care, Dementia, Sensor technology.
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Special Thematic Session 13
Challenges and Open Issues in Indoor and Outdoor Accessible Mobility

Mobility can be defined as "the ability to move or be moved freely and easily". Despite the advances in ICT, where mobile devices and smart objects (including sensors and internet of things technologies) become even more pervasive and powerful, mobility, and, in particular, accessible mobility is still an issue difficult to address, both in the indoor and outdoor environment. In fact, these two contexts let emerging different structural problems impacting the mobility of people with impairments under different aspects. Just to present some examples: architectural barriers can block the mobility of people with mobility impairments and elderly people, both in the indoor and outdoor spaces; missing accessible information can make hard enjoying a building or a urban path by vision impaired people; people with cognitive disabilities can face difficulty in orienteering due to the difficulty in using the wayfinding systems that can be perceived as complicated and unstructured. The goal of this special thematic session is to create an opportunity to put together experts investigating this topic of interest, and to discuss challenges and open issues in providing accessible mobility, considering both limitations in the current technologies (such as Bluetooth Low Energy technology accuracy for indoor context) and methodologies (such as relying on voluntary crowdsourcing or, on the contrary, on official sources as unique sources of information), and unexplored possibilities (such as innovative low-cost and non-intrusive sensing technologies).
Chairs: *Catia Prandi and Silvia Mirri*

Indoor Navigation for People with Visual Impairment

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Background: People with Visual Impairment (PVI) have limitation in functions of the visual system. It prevents them from seeing, communicating or doing daily activities such as navigation and shopping. So, we have proposed a solution to help them in the shopping process using visual tags. In this solution, we have implemented two applications for identifying PVI location and navigating indoor using QR codes and ArUco markers. We compared both applications to select which marker gives more accuracy and which one can be detected from a long distance.
Method: We have developed two applications. In the first application, QR codes are printed and installed in the environment at regular intervals. Each QR code store information about the current location. Then, an indoor map has been built using a graph to connect among all QR codes. In this graph, nodes represent QR codes while edges are labelled with the direction and the number of steps between nodes connected to them. This map is stored in a database to be used during navigation. When PVI use this application, they give their target location to it using voice commands. Then, it opens the camera to capture photos until a QR code is detected. The position details stored in the detected QR Code is used as an initial location. After that, it calculates the shortest path to the target location based on the stored map. PVI start walking to the appropriate direction using navigation commands. During navigation, PVI try to detect QR codes to identify their current location and receive continuous navigation commands. This process is repeated until they reach their destination point. The second application is the same as the first one, but it uses ArUco marker instead of QR codes. Both of them use camera calibration to make localization more accurate. We compared them to know which one gives more accuracy and which can be detected from a long distance.
Key results: We have tested the developed two applications to measure precision for detecting QR codes and ArUco markers using different distances (1 m, 2 m, 3 m and 4 m). The results show that ArUco markers can be detected from all mentioned ranges while QR codes can be identified from a range up to 1 m. Moreover, ArUco markers can be detected faster than QR codes because PVI do not need to focus the camera in case of ArUco. The results also show that QR codes cannot be identified if the image is blurred. However, ArUco markers give better results as they can be identified if

the image is blurred from a range up to 4 m. The results also show that QR codes and ArUco markers cannot be detected when PVI are moving fast.
Conclusion: We have presented two applications which used a smartphone camera to identify PVI location using visual tags. We have compared both of them, and the results show that ArUco markers are more accurate for indoor navigation than QR codes.
Acknowledgement: The authors thank the financial support of Széchenyi 2020 under the EFOP-3.6.1-16-2016-00015.
Keywords: Smartphones, Visually impaired, Indoor navigation, Visual tags.
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Understanding Mobility Device Users' Experiences of Discrimination due to Physical Inaccessibility: A Qualitative Study

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Background: By ratifying the United Nations Convention on the Rights of Persons with Disabilities (CRPD), Sweden has undertaken to implement the rights recognized in the Convention. The ability to move around in the community is an important part of enabling participation. According to the CRPD, public buildings and places have to be made accessible for mobility device users. In Sweden, physical inaccessibility is an often-occurring ground for discrimination in notifications to Equality Ombudsman (DO). The overall aim of this study was to generate new knowledge on how mobility device users experience discrimination due to inaccessibility, in what situations, and how they describe their experiences of being discriminated.
Method: Applying a qualitative approach, this cross-sectional study involved perspectives from occupational therapy and design/engineering. In order to understand mobility device users' experiences about inaccessibility and discrimination, a unique material consisting of notifications to DO during 2015–2016 was used. A thematic analysis of 74 notifications focusing on discrimination and use of rollators, wheelchairs (manual/powered), and powered scooters was conducted.
Key results: The analysis resulted in three themes; 1) testing the regulations and hope for a change; 2) being able to be treated and living like people without disabilities; 3) being able to participate and being independent in all environments. The results showed that persons who report discrimination due to physical inaccessibility take support in different laws and regulations, and some notifications revealed requests for compensations. The notifications described how different regulations and conventions serve as basis for persons with disabilities to have access to different physical environments on the same conditions as persons who don't have disabilities. Some notifications showed that persons who report discrimination ask how laws are adhered to. Several notifications described how staff at for example restaurants respond to guests in an undesirable manner, and situations where others do not understand their needs. The notifications described how mobility device users felt discriminated, and disadvantaged due to physical inaccessibility that excludes and makes them unable to live their lives as others and being able to get to places in the same way as others.
Conclusion: Based on mobility device users' own stories in notifications, this study highlights how people experience consequences of inaccessibility as discrimination. The study generates new knowledge on physical inaccessibility as a basis for discrimination. Such knowledge is important to clarify whether current standards sufficiently cater to the use of different types of mobility devices, and a contribution towards enhancing standards and guidelines. In addition, this study contributes with important knowledge on inaccessibility to the ongoing growth of Universal Design.
Keywords: Mobility device, Participation, Inaccessibility, Discrimination, Universal design.
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MEP CROWD: Improving Mobility of Users with Data and Images of High Quality

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Background: Mobile and web technologies allow people to actively participate in the enrichment of maps with accessibility information consisting of reports

and/or images on barriers or points of interest (e.g., Wheelmap, MEP App, mPASS, etc.): maps can display geolocalized pictures of barriers or report information about accessibility of buildings/streets, typically as non-accessible (often represented with a red icon/segment), accessible with some difficulties (yellow), accessible (green). Data collected with the help of users can improve their mobility, but one of the challenges consists in validating the crowd-sensed data, to publish only correct and accurate information.

Method: The proposed solution is based on a crowdsourcing engine and on a mobile application – called MEP Crowd – that allows users to visualize pictures of barriers reported by other users and answer some questions created by the engine on the declared type of obstacle (e.g., the user is reporting a narrow path), its criticality level (e.g., the user declares that it is not accessible) and about the quality of the pictures; the same questions are distributed to several different users. They are invited to answer some simple questions (e.g., "Does the picture show stairs?"), with "yes", "no", "I don't know". This allows to evaluate both the reliability of the person who uploaded the report, and – by comparing the answers of the single individuals with the answers provided by other users for the same task – to evaluate also the reliability of the evaluator itself.

Users of the MEP CROWD application are engaged with mechanisms based on gamification techniques (e.g., scoring systems, achievements, badges, etc.); a notification system gives feedback to the user about his progress through an established schedule. For questions related to possible explicit content, we apply an image recognition filter that discards those deemed to be harmful a priori; to be compliant with GDPR, the app MEP Crowd is PEGI 16.

Key results: The approach has been applied to over 3500 reports consisting of pictures and forms filled with data about obstacles reported in a survey done with middle school students accompanied by target users, and have been evaluated by people of different age and sex. About 25% of the images and reports were considered unclear: in case of single evaluations on the same barrier, they were discarded; instead, in the cases where more than one report of the same obstacle type exists in the same area, all reports can be merged into a single report characterized by an overall evaluation, which improves the average quality; moreover, images can be ranked and only the images with highest quality are shown to the final users.

Conclusion: MEP Crowd is a system that exploits crowdsourcing quality control techniques in an application that is completely based on people's reports: it identifies and keeps only valid answers, ranks images; evaluates the reliability of both the users providing the reports and the MEP Crowd users themselves.

Keywords: City Accessibility, Crowdsourcing, Mobile solutions.

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On Enhancing Campus Accessibility: Accessible Digital Signage, Wayfinding, and Navigation

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Background: Moving across the urban environment (both outdoor and indoor) could represent a barrier for citizens with disabilities. This is crucial in University Campuses, where students with disabilities must be supported in independently moving across buildings, offices, classrooms, and labs. Even if several laws and acts aim to guarantee buildings accessibility, there is a general lack of tailored and accessible information about buildings structure (including barriers and facilities). In particular, traditional signage reports many limitations in terms of: information, languages, accessibility, and visibility. Digital signage could cover this lack. Moreover, many studies are currently conducted to evaluate positioning technologies and algorithms, providing accessible wayfinding/navigation systems (for instance: NavCog). Our aim is to study and identify a system that integrates these two aspects.

Method: Our main idea is to exploit technologies for indoor positioning and wayfinding/navigation, integrating accessible digital signage, so as to compute personalized paths and routes (avoiding barriers, including facilities), providing accessible interface and interaction (by means of user's mobile devices). We have tested several algorithms and tools and then we have decided to use Beacon technology to identify users' position (according to user's proximity), while smartphone compass has been used to detect users' direction. We mapped the building with a graph, where the beacons correspond to the nodes. Each pair of adjacent beacons has been connected with an arc. Each arc can be marked as accessible, or not, with respect

to a specific disability (e.g., stairs are marked as inaccessible for wheelchair users). Each point of interest (classrooms, labs, restrooms, offices, etc.) has been associated with a beacon. We have designed and developed a prototype of a mobile app, providing two main app usage modalities: (i) reaching a destination within the building, with an accessible path (tailored on the basis of users' needs and preferences); (ii) exploring points of interest in the proximity of user's position. Once a user selects a destination, the prototype computes the shortest personalized path (Dijkstra's algorithm) between the beacon of the starting point (automatically detected) and the beacon of the destination. The path is then visualized and updated whenever a new beacon is sensed. The system has been designed and developed by involving users with disabilities, including them in the development team. The prototype has been designed for all: it provides an accessible interface and interaction for users with visual disabilities and it equipped wheelchairs users with tailored accessible paths within a building. The app prototype has been developed with ReactNative and it has been tested with iOS (with VoiceOver) and Android platforms.

Key results: We have set up an experiment within a historical building of the University of Bologna (Palazzo Riario), as a real case study, and we have involved a group of five students with disabilities (visual and motor/mobility ones), who provided feedback enriching the whole system, appreciating the potentiality of the involved technologies.

Conclusion: The proposed approach can be exploited in different contexts, integrated with outdoor systems, to support users with disabilities while autonomous moving in a campus.

Keywords: Accessible Wayfinding, Accessible Digital Signage, Internet of Things.

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Making Tourism Services Accessible to Visually Impaired Users Through a Mobile App

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Background: Tourism, defined as the practice of traveling for recreation, is not always accessible to all the people. This is particularly true if considering people with visual impairments who often experience difficulties in traveling and enjoying unknown destinations. For these reasons, different volunteers and associations started to provide services to assist visually impaired users while enjoying recreational activities.

With this in mind, we designed and developed a mobile application to aggregate this kind of accessible and trustworthy services and facilitate the meeting between supply and demand, exploiting innovative IT strategies.

We designed the application in collaboration with the Blind Bat association (Forlì, Italy), that deals with the accessibility of cultural and mobility services for the visually impaired users.

Method: The main idea behind this study is to create an accessible mobile application able to provide visually impaired users with a marketplace where to match supply with demand and where providers can meet the consumers' needs. In particular, the main goal is to equip users with an accessible multilingual mobile application where is possible to:

- Set personal preferences related to the graphical user interface (GUI) in term of colors and contrast, font size and family, on the basis of people with low visions and color-blind users' preferences;
- Discoverer touristic/cultural services provided by associations and volunteers, based on:
  - the proximity (exploiting the mobile devices GPS);
  - preferences (exploiting a recommendation system tailored on the basis of the users' needs and preferences, and previously enjoyed services);
- Rate and review enjoyed services, exploiting gamification to motivate users to contribute with feedback.

To design the application, we involved 100 users (49 suffering from low vision and 51 blind users), ranging from 13 to 79 years old, in a questionnaire in order to collect their insights to design such a mobile app. Moreover, we involved 15 users (7 blind users and 8 suffering from low vision) in the evaluation of the accessibility and usability of the app. Findings are presented in the next section.

Key results: The key findings emerged from the questionnaire, considering information about traveling, are:

- the majority of users (28%) travels "more than once a week", the 20% "more than once a year", the 15.5% "once a year", the 14.5% "once a month" (and so on);
- regarding the motivation behind the traveling, most of the users (36.5%) answered tourism and the 20% for visiting family and friends;

– the 86% declared they would like to travel more often, and, the same percentage claimed that having a mobile application will support them in traveling more.

After the developing of the mobile application (both for iPhone and Android OS), 15 users tested the application, to validate its accessibility and the provided functions. One interesting consideration that emerged during the evaluation was related to the sharing feature, considered really relevant for users.

Conclusion: Involving 115 users, we designed, developed, and evaluated a mobile application to facilitate the meeting between supply and demand, exploiting, personalized GUI, recommendation strategies, and gamification.

Keywords: tourism for all, gamification, mobile application, recommendation strategies.

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Shared Control System of Electric Wheelchair for Persons with Severe Disabilities using Reinforcement Learning Method

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Background: Persons with severe disabilities experience difficulties in operating an Electric Wheelchair (EW) mainly due to two reasons. First, some persons with disabilities do not have proper input devices because of their lack of muscle power and the deformation of their hands. Second, even special input devices are developed to meet their physical conditions, there is no guarantee that they can operate the EW correctly as they intend. For the first problem, we have made investigations to understand their physical functions. The structures and parameters of the input devices are then developed based on the quantitatively evaluation of their physical functions. The results show that almost all stages of persons with disabilities can use the novel input devices to give signals with their own operation. However, some of their operation is not accuracy enough to drive an EW especially in some complicated cases such as turning left or right in a narrow corridor even with the special designed input devices. This paper mainly focused on the second problem. Automatic driving wheelchair can partly solve the second problem, however, it is not helpful to maintain their residual physical functions. Therefore, it is necessary to develop a shared control system which can adjust the control weights between user and machine considering the characteristics of persons with disabilities.

Method: Based on the results of the previous research, after analyzing their operating characteristics, a shared control system using reinforcement learning method is proposed in this paper to adjust the control weight between user and machine to meet the requirement that making full use of usersą́ operating abilities and giving assistance when necessary. The reward for reinforcement learning is designed considering usersą́ operating burden, safety and comfort. The structure and the parameters of the reinforcement learning algorithms can also be designed to meet the different requirements from users such as less training times and the way the machine side intervenes.

Key results: Because the straight and yaw are two fundamental movements for EW driving, three courses including going straight in a corridor, stopping before an obstacle and turning left, are used in the simulation to verify the effectiveness of the method. According to the user's operating characteristics, two different situations are considered: users' turning signal is insufficient or users' turning signal is oversteered. The simulation results show that the proposed shared control system can gradually adjust the control weights between the user and machine, making the movement of the EW safe and comfortable while ensuring making full use of userą́s control signals. The entire convergence process is basically within ten trails.

Conclusion: A novel shared control system using reinforcement learning method is proposed to adjust the control weights between user and machine considering the characteristics of persons with disabilities. After several trails, the weights between users and machine can be adjusted to make full use of users' operating abilities and also make the movement of the EW safe and comfortable.

Keywords: Shared control, Electric wheelchair, Severe disabilities, Reinforcement learning

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The Effect of Footway Crossfall Gradient on one arm and leg drive wheelchairs

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Background: The footway crossfall gradient is a big barrier for wheelchair users. In Japan, the Law for Promoting Barrier-free Transport and Facilities for the Elderly and the Disabled and its guideline indicate that the footway crossfall gradient should be recommended to be 1% or less and it might be allowed to be no greater than 2% when it is unavoidable. However, many footway crossfall gradients above the standard remain.

Many people with stroke require manual wheelchairs for mobility. They propel wheelchairs with both the sound arm and leg. It is necessary to clarify the evidence for these guidelines how changes in a crossfall gradient affect the accessibility and the physical load of one arm and leg drive wheelchair users. And the objective assessment of barrier-free road construction to improve the accessibility of a wheelchair should be investigated. The purpose of study is to clarify the effect of footway crossfall gradient on one arm and leg drive wheelchairs by the wheelchair propelling force.

Method: The dynamic wheelchair propelling force was measured by using a torque meter equipped on a wheelchair (Kyowa Electronic Instruments) to analyze the required force when propelling on the footway crossfall. I experimented two kinds of gradients of 0.4% and 4% in actual footway.

In this study, I measured the physical load of 4% gradient because many footway crossfall gradient above the standard and compared it of 4% gradient and flat gradient. Subjects were five healthy persons simulating hemiplegia. They propelled wheelchairs with both one arm and leg for 30 meters. In addition, I measured how much the wheelchair deviated from a center line. The torque propelling force was measured when subjects propelled the hand rim at upslope and downslope side.

Key results: When subjects propelled wheelchair using an arm and a leg at the downslope side, the workload of the 4% gradient was significantly larger than the 0.4% gradient. On the other hand, at the upslope side, there was no significant difference in workload. However, in the 4% gradient, two subjects moved down the slope up to 40 cm from center line when they propelled wheelchair using an arm and a leg at the upslope side, and they applied a great deal of force in the opposite direction to apply the brakes. When wheelchair users propel an arm and a leg, it is thought that a greater force is applied to the leg than the arm.

Conclusion: Previous research has shown that there is a difference of force between the upslope and downslope sides of a two-hand drive wheelchair. Similarly, in this study, this difference of force can be achieved by applying a braking force to the upslope side of the wheelchair, and an increase in force on the downslope side. However, some subjects were unable to keep the wheelchair straight line against the force by the crossfall, it was found that the crossfll gradient was a significant barrier for wheelchair user with single arm and leg.

Keywords: Manual Wheelchair, Cross Slope, Physical Load, hemiplegia.

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Special Thematic Session 14
Pathological Speech Processing for Healthcare and Wellbeing

There are an increasing number of people with debilitating speech pathologies (e.g., due to stroke, Parkinson's, etc.). These groups face communication problems that can lead to social exclusion. They are now being further marginalised by a new wave of speech technology that is increasingly woven into everyday life but which is not robust to atypical speech. This thematic session will present research on the use of audio and speech processing for healthcare and wellbeing. In particular, we welcome papers on detecting, treating and living with pathological speech and associated conditions. It will bring together researchers from the fields of speech and language processing, medicine, psychology, as well as disciplines related health and aging and thus will contribute to the advancement of cross-disciplinary speech and language research.

Chairs: *Heidi Christensen*

Global Challenges in Pathological Speech Technology

Phil Green
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Picking up on the theme of AAATE19, I present a critical review of research and achievements in developing speech technology for people whose speech is abnormal. I will concentrate on what I know: how things have developed at the University of Sheffield, where this topic has been active for over 20 years. There have been notable successes: we have shown that

– It is possible to obtain good recognition results for people with severe dysarthria with very simple statistical models if you can train for each individual speaker.
– Speakers can improve their articulation given visual feedback based on the closeness of what they say to their best attempt so far.
– That such feedback can be used as the basis for speech training aids, where the therapist devises exercises for individual clients.
– That tailored speech recognition can be used as the basis for a communication aid by using recognition results to drive a synthesiser that 'speaks' in a normal voice.
– That the models used in statistical speech synthesis can be adapted to produce a normal voice which captures the characteristics of a client with disordered speech.
– That it is possible to restore the individual voice of someone who can no longer speak at all by a learned transformation from articulatory sensor data to acoustics.

However, the impact of this work has been limited. It tends to produce good demonstrations, papers and Ph.Ds but there is little which is deployed in real clinical applications. I will discuss why this is so and conclude with suggestions about how the community might work together to improve matters. In particular,

– A common problem is in finding enough data for machine learning. We need to automatically collect data from systems which are already in use and, as far as possible, to share this data.
– We need to work towards systems which adapt to their users, rather than insisting that the users adapt to them.

Keywords: speech technology, disordered speech, impact.
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Acoustic Features to Support the Perceptual Evaluation of Accent Production in Dysarthric Speech

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Background: Prosodic disorders are reported in a significant number of clinical conditions and have a negative impact on speech intelligibility and comprehensibility. Research on acoustic features of prosody in pathological speech is rather scarce. Previous studies on sentence accent production correlate this prosodic function with movements of the fundamental frequency (F0), intensity and duration. However, it is unclear how differences between accented and non-accented syllables are objectively expressed and how these changes in F0, intensity, and duration are related with the sentence, and with the preceding segment of the accent location. The goals of this research are to identify relevant acoustic features of sentence accent production in Dutch, including derived features of F0, intensity, and duration, allowing the classification between accented or unaccented syllables in an accent production task and to objectively demonstrate the similarities and differences between healthy and speakers with dysarthria in sentence accent production.
Method: Persons affected with dysarthria are the principal population in this study because in healthy speech the strategies for accent production are more consistent, 80 adult speakers (30 healthy and 50 with speech impairment) were asked to produce 3 pairs of sentences with different accent positions. Three experts performed perceptual judgments of the samples. An acoustic analysis of all speech samples was performed, a set of 20 features was generated for each sentence and was divided into three different groups, resulting in feature sets related to frequency, intensity, and duration within the target syllable, in contrast with the previous syllable and also in contrast with the entire sentence. These features were used as input for a Linear Discriminant Analysis. A statistical analysis was performed (two-sample Kolmogorov-Smirnov test), aiming to find potential differences in the accentuation process of speakers with and without dysarthria.
Key results: Outcomes of the analysis show the relevant acoustic features used to detect accented and

unaccented syllables and reveal that healthy speakers mainly rely on the following features to produce a perceptually detectable accent: a change in frequency within the target syllable with simultaneous increase of intensity and contrast in frequency between the target syllable and the previous syllable. Speakers with dysarthria mainly use the contrast in frequency and intensity between the target syllable and the previous syllable rather than the contrast with the rest of the sentence. They also use durational parameters as an element in prosodic accent production. Although in both groups some common features are used, they differ significantly ($p < 0.01$) in the accent production. The latter was established by means of newly developed acoustic features.

Conclusion: The results of this study provided a limited set of acoustic features to characterize sentence accent in a reliable way. This research allows a better understanding of accent production and the different strategies used by healthy and speakers with dysarthria. It also opens an opportunity for the development of an objective and automatic tool to evaluate contrastive stress tasks. This study could be inspiring for speech-language pathologists looking for compensatory strategies in patients with speech disorders and more appropriate therapy methods.

Keywords: Sentence accent, Dysarthria, Acoustic features, Prosody.

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Enabling Early Detection and Continuous Monitoring of Parkinson's Disease

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Background: Parkinson's disease (PD) currently affects 6.3 million people worldwide, and with an aging European population, this number is set to rise. People with this incurable disease suffer from weakness, tremor, and rigidity. Biomarkers of the disease have yet to be fully investigated, and so expensive and time-consuming clinical assessments are required but all too often never carried out. Early detection of the disease and continuous monitoring of its progression can greatly aid in the application of therapies to delay further symptoms and help patients and family manage it both mentally and physically. As symptoms of PD manifest in the voice, we are working towards automatic recognition and monitoring of Parkinson's disease directly from the voice. Through embedded sensors, PD tests can be carried out at ultra-low-cost, are highly scalable, do not require a visit to a clinic, and can generate high-frequency monitoring data. Our study focuses on differentiating between healthy and diseased individuals, and predicting the severity of a patient's disease.

Method: Using openSMILE, our large space feature extraction toolkit, we analysed audio samples collected from a clinical trial featuring 20 patients in various stages of the disease along with a control group of 30 subjects of the same age range. We were also provided with UPDRS Scores which denote the severity of each patient's condition on a scale from 0–199 (worst). The audio samples contain extended vowel utterances "aah", successive consonant-vowel utterances "pa-ta-ka", read speech, and free speech. Several thousand direct and derived audio features were evaluated w.r.t. their correlation with the test subjects. Support vector machine (SVM) classification models were used to differentiate between patients and healthy subjects, and linear regression models were implemented to predict the patients' severity of the disease. For this part of the study, only the extended vowel and successive consonant-vowel utterances were utilized.

Key results: Several audio features have been shown to correlate well with our binary classification tasks. In the case of extended vowel utterances, features which showed strong correlation were MFCC coefficients, Jitter, F0 and Harmonic-to-noise ratio. In particular, F0 variations and discontinuities proved to be the most useful. Our algorithms were able to provide a clean separation between healthy subjects and patients with PD, with an average unweighted accuracy of 91% on subject independent folds using a combination of consonant-vowel and vowel sounds. In addition, the UPDRS scores were predicted with a Pearson correlation of 0.55 using only the successive consonant-vowel sounds.

Conclusion: We have successfully integrated the openSMILE technology in low-resource embedded systems like smartphones, but more importantly, in low-energy wearable sensors such as smartwatches. This is crucial since it enables the continuous monitoring of a patient's condition through a minimally invasive device placed on the patient themselves. This de-

vice would monitor the patient's normal speech in everyday life. More accurate measurements could be frequently obtained through structured voice tests (such as extended vowel utterances), performed on a smartphone by any health care assistant.

Keywords: openSMILE, Parkinson's disease, wearable sensors.

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Apkinson: a Mobile Solution for Multimodal Assessment of Patients with Parkinson's Disease

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Background: Parkinson's disease is a neurological disorder that produces motor impairments in the patients, including bradykinesia, resting tremor, and different speech impairments. The motor symptoms progress differently among patients, thus it is important to monitor their symptoms individually and continuously. The continuous monitoring is not always possible for many patients, especially those with low accessibility to healthcare services. There is a need for a system to track the disease progression of the patients individually. A smartphone application that combines speech and movement analysis could be a suitable mechanism to monitor the disease progression. Such application will be beneficial for patients and caregivers to be informed about the current stage of the disease; and for clinicians to make timely decisions regarding the medication and therapy of the patients. Various applications have been developed to monitor Parkinson's patients. However, most of them only evaluate the upper and lower limbs symptoms using the inertial sensors from the smartphone. There are no applications to perform a robust analysis of the speech state of the patients. On the other hand, related studies have shown that it is possible to evaluate the speech impairments of Parkinson's patients using signals captured with the smartphones. However, such studies only consider the smartphone to record the speech data, without providing a feedback mechanism to the patient about the current state of the disease.

Method: We introduced a new application called Apkinson to evaluate continuously the speech and movement symptoms of Parkinson's patients, providing a feedback mechanism about the current stage of the disease. The patients are asked to do different speech and movement exercises every day, which are selected from an exercise bank that contains a total of 35 exercises. The speech exercises include the phonation of sustained vowels, diadochokinetic utterances, several sentences that the patient has to read, and the description of images that appear in the screen. On the other hand, movement exercises are captured using the inertial sensors of the smartphone to evaluate symptoms in the upper and lower limbs, such as postural tremor, kinetic tremor, finger tapping, gait deficits, among others. At the end of the exercise session, Apkinson evaluates the performance of the patient, while it keeps a register of the results from previous sessions. This analysis will allow the assessment of the progress of the disease of the patients.

Key results: At the moment, a group of 20 patients is testing the functionalities of Apkinson. They performed all the speech and movement exercises and received the proper feedback about their performance. The speech state is evaluated in terms of phonation, articulation, and prosody, while the assessment of movement deficits is evaluated according to the tremor amplitude and the stability of the movements.

Conclusion: We introduced Apkinson, a new smartphone application designed to capture speech and movement signals using the patient's smartphones when they perform different exercises. The patients receive feedback about their performance after doing the exercises. Further releases of Apkinson will include robust models to predict the neurological state of the patients.

Keywords: Parkinson's disease, Mobile application, Speech assessment, Motor assessment.

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Generating Phonological Feedback for Evidence-based Speech Therapy

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Background: The number of people with debilitating speech pathologies due to stroke, Parkinson's or other age-related diseases, is ever-increasing. Tools

to remedy the communication problems or otherwise support the patients thus have high social value. The main points of attention for support are: detection, therapy and assisted living. Our research focuses on speech therapy, specifically on improving the ASISTO e-health tool for training and evaluating pathological speakers. Below, we briefly list the main properties of the existing tool and possibilities to make the e-therapy tool more accessible, more engaging, and more individually targeted. The current tool is designed for Dutch speakers. Expanding to multiple languages will significantly extend the population that benefits from the tool. The current version covers a limited set of pathologies, such as dysarthria and Laryngectomy. A more versatile and robust model can be obtained by learning commonalities across different pathologies. Providing detailed feedback, rather than intelligibility, based on phonological features is expected to make the e-therapy more effective.

Method: Having access to more data in multiple languages is a vital part of the solution to achieve the aforementioned objectives. To collect and aggregate the data, we collaborate with clinical institutes (UMC-Utrecht, NKI-Amsterdam) and the industrial sector (EML-European Media Laboratory). 54,231 speakers from ASISTO and COPAS database are used, with recordings of 1 minute/speaker and the target label quality as follows:

	Good	Average	Bad
ASISTO	65.45%	23.64%	10.91%
COPAS	89.61%	6.93%	3.46%

Key results: Pathological data is very diverse and sparse in nature. Handling the more diverse and larger data-sets requires efficient and flexible training procedures to extract the phonological features from the audio. Switching from a Multi-Layer Perceptron (MLP) implemented in C to Pytorch was a first step to achieve the desired speedup and flexibility. As a result, training time is now reduced with a factor of 20 without loss in performance. To further improve the model, we focus on: *Robustness:* Robust machine learning paradigms on unseen data (e.g., Dropout, mini batch normalization, weight decay) will be adopted. To combat overfitting even further, we aim for compact models that incorporate constraints base on physiology. *Exploiting commonalities across pathologies/languages:* Despite the differences in pathologies and exercise type, we expect that modified training algorithms could lead to a single overarching and multipronged model. Exploiting cross-language commonalities is due to the use of phonological features straightforward. *Detailed feedback based on phonological features:* Phonological features provide extra support to the therapists in diagnosing the main problems, tracking the progress of the patient and the efficacity of the exercises (evidence-based therapy). Patients benefit as well from more informative feedback.

Conclusion: Learning commonalities across pathologies and across languages should make the ASISTO tool more versatile and more robust. Also employing phonological features provides a rich analysis of the speech which is expected to benefit both the speech therapists and the patient, hence making the e-therapy tool more effective.

Keywords: TAPAS, ASISTO, Pathological speech processing, e-Therapy, Phonological feedback.

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From VIVOCA to VocaTempo: development and evaluation of a voice-input voice-output communication aid app

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Background: People with severe physical disabilities often have difficulty accessing communication aids via commonly available access methods. An alternative approach, using dysarthric speech recognition as an access method, was described at the AAATE conference in 2007. The voice-input voice-output communication aid (VIVOCA) was not developed for the commercial market at the time, partly due to the limitations of available hardware. Subsequent widespread availability of tablet computers led to the further development of the VIVOCA concept, and a commercially available product, VocaTempo, has been released as a tablet-based app aimed at children and young people. This paper describes the development and evaluation of VocaTempo.

Methods: A two-stage collaborative R&D project involving a public-sector AT provider, a university research centre and company developing speech therapy and communication apps, took place over 18-months. Iterative design, development and evaluation resulted

in an app, which uses the (dysarthric) speech of individual users as an access method to produce clear synthetic speech output phrases. Two evaluation phases were carried out; the first was a proof of concept evaluation, to assess performance, usability and acceptability within a controlled environment, and to identify key user requirements. The second was a 'real life' evaluation, to the assess performance, usability and acceptability, of an updated app (based on phase 1 findings), in everyday usage environments, and to evaluate its potential impact, including how VocaTempo may be incorporated into usersąf communication strategies. The evaluations used a mix of qualitative (observation, interviews with users and therapists) and quantitative (task completion, communication speed) methods.

Results: The VIVOCA concept and speech recognition technology were successfully incorporated into a professionally produced tablet-based app.

First evaluation: Five individuals aged 19–22 years trialled VocaTempo. The app was shown to be highly usable, reliable and easy to learn to use. For 4 out of 5 participants, the app was faster than their current communication method. Average speech recognition rate was 94%, ranging from 87.5% to 100%. The appąfs rejection of vocalisations due to mis-timing of vocalisations and background noise were issues which needed addressing. All participants found the app to be acceptable and most wanted to continue to use the app in the future. A range of requirements for further development of the app were identified.

Second evaluation: Eleven individuals aged 5–21 years trialled the re-developed app. The app recognised 75–100% of vocalisations in controlled conditions, and recognition increased with use. Participants responded positively to the concept of the app and gave positive feedback to the set up procedure. Qualitative data suggests the app was suitable for use in real life situations, and provided examples of how users may utilise the app for different purposes and in different scenarios. We identified some feature and bug issues and developed practice recommendations on mounting, access, use of external microphones, and user support.

Conclusion: The development of the VIVOCA concept has resulted in a tablet-based app that successfully uses speech recognition as a communication aid access method. The app, VocaTempo, has potential benefits for a variety of children and young people.

Keywords: Communication aid, speech recognition.

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Special Thematic Session 15
Robotics and Virtual Worlds for wheelchair users – from ideas to reality: Innovation, Training, and Roadmap to Market (The ADAPT project)

Assistive Technologies (AT) in the form of Socially Assistive Robotics (SARs) and smart Electric Powered Wheelchairs (EPWs) can be effective tools to empower people with mobility disabilities and improve social interactions, independence and autonomy in everyday life, leading to positive emotional wellbeing. However, driving an EPW safely can be challenging due to range of barriers and this leads to AT abandonment and social isolation. Existing barriers in the uptake of AT solutions for EPW users include interdisciplinary communication, standardization of technology, interoperability, limited involvement of users, lack of AT training for healthcare professionals, and synergies between researchers and markets.

In this Special Thematic Session, we will present papers linked to a European collaborative project 'Assistive Devices for empowering disAbled People through robotic Technologies' (ADAPT). The ADAPT project aims to tackle the above mentioned challenges in three ways. First, the project is adapting existing technology, and creating new innovative assistive technologies based on advances in robotics, namely an intelligent connected wheelchair equipped with Driving Assistance (DA) technologies and a wheelchair driving simulator based on Virtual Reality (VR), for the purpose of testing smart wheelchairs and training/rehabilitating users. Second, the project is filling the gap in the current healthcare workforce development and training by developing training materials and sessions to engage more efficiently the healthcare professionals with the use of AT solutions. Third, the ADAPT partnership is developing a roadmap of relevant stakeholders and market events to promote the results of the project and ensure the sustainability of the technology developed. The partnership involves fifteen organisations in UK and France, including Health Trusts, Universities and AT companies, with teams of engineers, healthcare professionals and clinical scientists who are collaborating to build interdisciplinary networks and approaches to AT technology development, healthcare professional AT training, and transfer of knowledge to markets. The project is funded by Interreg VA France (Channel) England Programme and runs for 4 years (2017–2020).

The papers presented in this session will discuss project progress in the respective areas of AT and so-

cially assistive robotics for wheelchair users, AT training and professional development, and sustainability of AT solutions in the health and social care sector.
Chair: *Eleni Hatzidimitriadou*

ADAPT: An EU Multidisciplinary Project in Robotics Rehabilitation for Empowering People with Disabilities

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Background: Ageing societies and the increase in chronic disabilities are irrevocable trends in the EU. Many people with complex disabilities face increased isolation due to a loss of independent mobility. Several studies highlight the key role of innovative Assistive Technologies and "smart" Electrical Powered Wheelchair as effective tools to empower disabled people and improve their social inclusion. Nevertheless, standardization, interoperability, limited involvement of users, lack of specialist training for health professionals impede the uptake of such innovations. The purpose of this presentation is to give an overview of the European INTERREG VA FCE ADAPT project "Assistive Devices for empowering disAbled People through robotic Technologies"[1] which aims to develop, promote the undertaking of innovative assistive technologies based on Robotics and Information & Communication Technologies for the benefit of disabled people.
Method: A transdisciplinary consortium of French and English partners formed the 4-year ADAPT project, starting in May 2017. The project aims to overcome the barriers to the uptake of assistive technology by developing:

- Driving assistance technologies integrated into a powered wheelchair to compensate for user disabilities and to monitor and report changes in users' health
- A virtual reality powered wheelchair simulator platform to give to the user an immersive experience of driving a smart EPW. Professionals will assess the suitability of the EPW for particular patients and environments and gain understanding from the user perspective.
- Developing innovative assistive technologies training programs to fill the current gap in the healthcare training programs about digital innovative technologies in the field of health and disability
- Formalizing agreements between research institutions and companies to facilitate the uptake of the ADAPT's results by the market.

Key results: An overview of the ADAPT preliminary results will be presented. A specific focus will be pointed out on:

- The virtual reality driving simulator system for which a preliminary study has been conducted with volunteers to evaluate the benefice of the motion platform regarding the kinestosis issues;
- The driving assistance systems integrated on the powered wheelchair for which tests have been conducted in labs;
- The first units of training programs created for the healthcare professionals;
- The first activities carried out in order to make the uptake of the ADAPT's results easier by the market

Conclusion: The talk will give an overview of the ADAPT project: context, challenges, methodology of work and preliminary results. This presentation will also highlight the next stages of the project regarding the development and tests of the technological systems, the next training programs to be developed and the actions undertaken to favor the spreading to the ADAPT results to the market.
Keywords: Assistive technologies, Robotics, Virtual reality, Training, Market accessibility.
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[1] The INTERREG FCE Programme is a European Territorial Cooperation programme that aims to fund high quality cooperation projects in the Channel border region between France and England. The Programme is funded by the European Regional Development Fund (ERDF).

Artificial Intelligence for Safe Assisted Driving Based on User Head Movements in Robotic Wheelchairs

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Background: Wheelchair users do not always have the ability to control a powered wheelchair using a

normal joystick due to factors that restrict the use of their arms and hands. For a certain number of these individuals, which still retain mobility of their head, alternative methods have been devised, such as chin-joysticks, head switches, or, sip-and-puff control. Such solutions can be bulky, cumbersome, unintuitive, or, simply uncomfortable and taxing for the user. This work presents an alternative head-based drive-control system for wheelchair users.

Method: Using recent advancements in the field of deep-learning networks, we have developed a drive-control solution based on two popular neural network models, which make use of a low-cost RGB camera to track the user's head and estimate its position and orientation. Head movements are translated to drive commands by which a user is able to control the speed and direction of the wheelchair. This control system works on top of our collision avoidance algorithm which adds an extra level of safety and prevents movements that could occur from any misinterpreted input. Head-tracking is achieved in two stages. The first stage uses the popular YOLO deep-learning object detection algorithm which we have re-trained specifically for face detection. The second stage uses a residual neural network (ResNet), re-trained specifically for estimating head pose. The YOLO network detects the user's face from the camera stream in real time, which is then extracted from the image. The face detected is subsequently passed to the ResNet neural network, which outputs an estimation of the yaw and pitch of the head. These two outputs are translated into drive commands, forward-backward for pitch, and left-right for yaw. The system runs under the ROS (Robot Operating System) framework, and all processing is achieved using a Jetson TX2 board, an embedded AI computing device with a CUDA enabled NViDIA GPU which is powered from the wheelchair batteries.

Key results: Trials with twenty participants (not disabled) were conducted in a simulated environment with a joystick in-the-loop setup as baseline for evaluation, and an RGB camera for head-tracking. Two setups were tested: with, and without collision avoidance. With the exception of three expert users of the head-tracking system, who completed the course without collisions, first-time users did not successfully pass the course. With the collision avoidance system, all participants completed the course without collisions, both using head-tracking and joystick. Average time to completion using head-tracking was 70.16% ($\pm$ 25.78%) higher than using the standard joystick without collision avoidance. When driving with the standard joystick, the collision avoidance system introduces an average 22.75% ($\pm$ 14.56%) increase in completion time.

Conclusion: Our system demonstrates the practicality of using innovative deep-learning artificial intelligence coupled with a collision avoidance system for head-controlled driving of powered wheelchairs. This approach could prove preferable to currently available solutions because of its simplicity and efficiency. Additionally, input from the head-tracking system could be redirected, in order to control a tablet or smartphone, or send commands to a smart home or other Internet of Things (IoT) devices.

Keywords: Artificial Intelligence, Robotic wheelchair, Head-tracking.

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A Simulator to Promote the Return to Work of Wheelchair Users

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Background: Return to work and participation in the community life have been recognized to improve wheelchair users (WUs) quality of life. Therefore, the development of strategies to help them recover their autonomy in the activities of daily living (ADL) represents a key challenge. Virtual Reality (VR) has recently emerged as a promising tool for providing end users with a multi-sensory simulation of diverse scenarios, in an interactive, controllable, repeatable and safe environment, increasing the possibility to acquire new skills. In this work, a VR-based simulator aimed at promoting the work reintegration for WUs has been designed and developed.

Method: The needs of WUs, as well as the characteristics of current clinical practice in standard care, have been investigated to define the requirements of the VR-based wheelchair simulator. Three different scenarios

have been identified to properly address mobility and ADL-related issues: (1) driving the wheelchair in an outdoor environment, and moving around and accomplish specific tasks (2) in the house and (3) at the workplace.

Key results: Up to now, only the outdoor environment has been developed. It specifically addresses users' mobility limitations, thus it requires the WU to overcome different barriers, such as ramps or steps, and to avoid moving obstacles, i.e. pawns and cars. The first prototype has been deployed to run on the GRAIL platform (Gait Real-time Analysis Interactive Lab). An appropriate seat – to be anchored on the GRAIL treadmill, together with the two wheelchair's rear wheels – has been designed in order to fit different anatomical features and thus to be usable by as many users as possible. Specific modules were developed using GRAIL commercial software (D-Flow) to handle user's navigation in the virtual scene, which is rendered in real-time by using OGRE rendering engine.

The currently-developed application allows the simulation of both electronic and manual wheelchair; in the former case, the user will have the chance of using a joystick, controlled either with the hand or the chin. In the latter, markers placed on the wheelchair's wheels are used to determine the direction and the velocity of the user's motion.

Future Works: The deployed virtual environment will be validated in the next months enrolling both unexperienced ($n = 10$) and experienced users ($n = 10$, WST-Q > 80). Data regarding the whole users' experience will be collected and analyzed to assess the system usability and acceptance, and thus the feasibility of a training program exploiting VR dedicated to WUs. The other two scenarios (i.e. house and workplace-contextualized training) will be developed and validated as well. The final step foreseen in the project is the development of a platform independent from the GRAIL. New functionalities will be implemented using Unity 3D as game engine to allow the navigation in the scenes using a Head Mounted Display: this should increase users' immersion and engagement. The GRAIL treadmill will also be replaced with a Steward platform, plus two motors acting on the wheelchair's wheels, for the correct perception of vestibular and haptic feedbacks.

Keywords: wheelchair user, virtual reality, training.

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A Literature Review of the Challenges Encountered in the Adoption of Assistive Technology (AT) and Training of Healthcare Professionals

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Background: Long-term disabilities often result in loss of autonomy and social interaction. Accordingly, there is a demand for Assistive Technology (AT) devices to enable individuals to live independently for as long as possible. However, many people experience difficulties in obtaining and using AT. This paper presents findings from a narrative literature review undertaken as part of the development of AT training for healthcare professionals, one of the work areas of the ADAPT project (Assistive Devices for Empowering Disabled People through Robotic Technologies), funded by EU INTERREG France (Channel) England. The results of the review informed the design of a survey of healthcare professionals regarding their views and experiences of AT and the development of AT training.

Method: The review sought to understand challenges encountered in the adoption and use of AT as well as how training of healthcare professionals in AT takes place. A narrative approach was adopted as the most appropriate way to synthesise published literature on this topic and describe its current state-of-art. Narrative reviews are considered an important educational tool in continuing professional development. An initial search was conducted via databases in the UK and France, including CINAHL, Academic Search Index, Social Sciences Citation Index, BDSP (Base de données en Santé Publique), Documentation EHESP/MSSH (Ecole des Hautes Etudes en Santé Publique/Maison des Sciences Sociales et Handicap), Cairn, Google Scholar and Pubmed. Inclusion criteria for the review included: covering issues relating to AT provision and training, English or French language, and published from 1990 onwards. Application of these criteria elicited 79 sources, including journal papers (48), reports (11), online sources (11), books (6) and conference papers (3). Sources were thematically analysed to draw out key themes.

Key results: The majority of papers were from USA and Canada (27), then UK (20) and France (19). Others were from Europe (7), Australia (3), country unknown (2), and one joint UK/France publication. The main source of literature was journal papers (48), of which the most common types were practice reports (18), evaluation surveys (10) and qualitative studies (9). The review uncovered a number of key challenges related to the adoption of devices, including: difficulty defining AT across disciplines, lack of knowledge of healthcare professionals and users, obtrusiveness and stigmatisation AT users can experience when using devices, and shortfalls in communication amongst professional groups and between professionals and users. These issues can lead to abandonment of AT devices. Furthermore, substantial barriers to healthcare professionals exist, including inconsistent provision and quality of training, lack of evaluation of training, lack of resources and funding, shortage of qualified professionals to teach, and the increasingly rapid development of the technologies.
Conclusion: Support, training and education for prescribers, distributors, users, and their carers is vital in the adoption and use of AT. Evidence indicates a need for comprehensive education in the AT field, as well as ongoing assessment, updates and evaluation which is embedded in programmes.
Keywords: literature review, challenges adopting AT care solutions, AT training of healthcare professionals
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A Survey of Assistive Technology (AT) Knowledge and Experiences of Healthcare Professionals in the UK and France: Challenges and Opportunities for Workforce Development

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Background: Assistive Technologies (AT) in healthcare can increase independence and quality of life for users. Concurrently, new AT devices offer opportunities for individualised care solutions. Nonetheless, AT remains under-utilised and is poorly integrated in practice by healthcare professionals (HCPs). Although occupational therapists (OTs), physiotherapists and speech and language therapists (SLTs) consider that AT solutions can offer problem-solving approaches to personalised care, they have a lesser understanding of application of AT in their practice. In this paper, we report findings of a survey on AT knowledge and experiences of HCPs in UK and France. Training needs also explored in the survey are presented in a separate paper on development of online training for the ADAPT project.
Method: A survey of 37 closed/open questions was developed in English and French by a team of healthcare researchers. Content was informed by published surveys and studies. Email invitations were circulated to contacts in Health Trusts in UK and France ADAPT regions and the survey was hosted on an online platform. *Knowledge* questions addressed AT understanding and views of impact on user's lives. *Experience* questions focussed on current practices, prescription, follow-up, abandonment and practice standards. 429 HCPs completed the survey (UK = 167; FR = 262) between June and November 2018.
Key results: Participants were mainly female (UK 89.2%; FR 82.8%) and qualified 10+ years (UK 66.5%; FR 62.2%). A key group in both countries were OTs (UK 34.1%; FR 46.6%), with more physiotherapists and SLTs in UK (16.8%, 16.8%; vs. FR 6.5%, 2.3%), and more nurses in France (22.1% Vs. UK 10.8%). More HCPs were qualified to degree level in France (75.2%; UK 48.5%, $p < 0.001$). In terms of knowledge, all HCPs agreed that AT helps people complete otherwise difficult or impossible tasks (UK 86.2%; FR 94.3%) and that successful AT adoption *always* depends on support from carers, family and professionals (UK 52.7%; FR 66.2%). There were some notable differences between countries that require further exploration. For example, more French HCPs thought that AT is provided by trial and error (84.7%, UK 45.5%, $p < 0.001$), while more UK HCPs believed that AT promotes autonomous living (93.4%; FR 42.8%, $p < 0.001$). Also, more French HCPs considered that AT refers exclusively to technologically-advanced electronic devices (71.8%, UK 28.8%, $p < 0.001$). In both countries, top AT prescribers were OTs, physiotherapists and SLTs. Respondents had little/no knowledge in comparing/choosing AT (UK 86.8%; FR 76.7%) and stated they would benefit from interdisciplinary clinical standards (UK 80.8%; FR 77.1%). A third of HCPs did not know if AT users had access

to adequate resources/support (UK 34.1%; FR 27.5%) and rated themselves as capable to monitor continued effective use of AT (UK 38.9%; FR 34.8%).

Conclusion: Knowledge and application of AT was varied between the two countries due to differences in health care provision and support mechanisms. Survey findings suggest that HCPs recognised the value of AT for users' improved care, but had low confidence in their ability to choose appropriate AT solutions and monitor continued use, and would welcome AT interdisciplinary clinical standards.

Keywords: survey of AT knowledge and practice experiences, healthcare professionals, UK, France

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Training Needs and Development of Online AT Training for Healthcare Professionals in UK and France

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Background: Assistive Technology (AT) solutions for people with disabilities has become part of mainstream care provision. Despite advantages of AT on offer, abandonment and non-compliance are challenges for healthcare professionals (HCPs), introducing this technology to clients. Studies of abandonment reveal that 1/3 of all devices provided to service users end up stored unused. Key need is training to make informed decisions about AT tailored to individual needs and circumstances. In an online survey undertaken by the ADAPT project, HPCs identified AT training needs and barriers. Currently, a programme is being developed aimed at introducing AT concepts and enhancing practices to a wide range of HCPs.

Method: Survey questions explored gaps, availability, qualifications and barriers to AT training in England and France. A series of consultation meetings with ADAPT partners took place. An advisory group consisting of longstanding AT users and their formal/informal carers and HCPs (occupational therapist, speech and language therapist, psychologist and biomedical engineer) contributed to the discussions on survey findings, development and evaluation of AT training for HCPs, key content areas and means of delivery.

Key results: HCPs had no AT specific qualifications (UK 94.6%; FR 81.3%) nor in-service AT training (UK 65.1%; FR 66.4%). They either did not know of AT courses (UK 63.3%) or knew that none existed (FR 72.5%). Barriers to AT training were mainly local training (UK 62.7%, FR 50%) and funding (UK 62.7%, FR 55.7%). Some training priorities were clearer for French HCPs – overall knowledge of AT devices (82.1%, UK 45.8%), customization of AT (65.3%, UK 30.1%), assessing patient holistically (53.4%, UK 25.3%), educating patient/carers (56.5%, UK 28.3%) ($p < 0.001$). Variances may be due to differing country-specific HCP education approach. A third of both groups highlighted also abandonment, client follow-up, powered wheelchair training and prescribing AT.

To bridge gaps in knowledge and identified training needs of HCPs, the online interactive training programme starts by introducing foundations of AT, including definitions, types/uses of AT, legislation/policies and AT in practice. More specialist units build and expand on specific areas, e.g. AT for mobility, communication, assessment and evidence-based practice. The biopsychosocial model of Health and World Health Organisation's (WHO) International Classification of Functioning, Disability and Health (ICF) framework underpin development of content. ICF shifts focus from disability to health and functioning, in line with a social model of rehabilitation.

E-learning comprises existing videos, AT textbook material and bespoke animated presentations. Self-assessment and evaluation of training are embedded and learners receive certificate of completion. Training was piloted to a group of HCPs trainees and post-registration HCPs who commented on relevance of AT content, clarity, accessibility of presentation, and usefulness. Users found training very useful, especially legislation/policies and AT literature.

Conclusion: Overall, survey results suggest that both UK and French HCPs' training on AT solutions is limited and highly variable. There is need for cross-channel AT professional competencies, availability of work-based training and funding support. Development of online, interactive training aims to increase professional confidence and competence in this area as well as the evidence base for AT.

Keywords: AT training needs; healthcare professionals; barriers to training; training priorities; development of online AT training
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Integrating Ride Dynamics Measurements and User Comfort Assessment to Smart Robotic Wheelchairs

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Background: Individuals relying on wheelchairs for mobility are subject to risk of injury due to exposure to whole-body vibrations for prolonged time as per ISO 2631-1. Our study evaluates the feasibility of integrating ride dynamics measurements (i.e. vertical accelerations) as expressions of user travel comfort assessment to smart robotic wheelchairs. This will also help to mitigate injury risk and discomfort by using real-time electronic measurement systems to ensure adaptation of wheelchair movement dynamics (acceleration and speed) to the type of ground surface.
Method: The INVACARE Spectra XTR2 electric wheelchair, weighting 98 kgs, was used in seven different surfaces, indoors and outdoors. It was driven for fifteen minutes by one of the authors (body mass 88.6 kgs, height 185 cm) for 322 meters. The surfaces were: Uneven Pavement Slab, Damaged Tarmac Road, Undamaged Tarmac Road, Pavement Bricks, Carpet Floor, Tiled Floor, and Inclined Concrete. Average travel speed was 0.339 m/s. In-house designed sensor devices were placed on the metal frame of the wheelchair (location without suspension) and under the seat (location with suspension). Collected data was filtered and analysed using MATLAB. For each terrain type, the mean, standard deviation, minimum, and maximum of vertical accelerations were calculated, along with Maximum Transient Vibration Value (MTVV). MTVV measures the maximum amplitude of instantaneous frequency-weighted acceleration at measurement time. ISO 2631-1 and related literature suggest MTVV as one of the main indicators of injury risk and ride comfort.
Key results: Results show, for both with and without suspension measurements, Tiled Floor has the highest MTVV, indicating it would be the most uncomfortable and, depending on the value obtained, the riskier to cause an injury if traversed for long time. Different types of tiled floors would produce varied MTVV measurements. For this reason we propose that a continuous monitoring system is required to be integrated to smart wheelchairs. In most cases, maximum accelerations and MTVV were higher when measured with suspension than without. Our hypothesis is that suspension has dampening effects on vertical accelerations caused by the unevenness of the terrain, but, it can, under certain conditions, attenuate also the overall amplitude. Thus, it is important to measure both affected and not affected by suspension locations. Remaining tested surfaces were ranked for discomfort as expected (using MTVV and mean vertical acceleration statistics), with Pavement Bricks second and Damaged Tarmac Road third, while Undamaged Tarmac Road produced the lowest values (i.e. less overall vibration).
Conclusion: Different terrain types produce levels and types of vibrations which are not properly mitigated by the usual wheelchair suspensions (typically based on dual springs). This affects ride comfort (expressed by MTVV measurements) which should be considered in smart wheelchair controller design to improve user experience enhancing safety and wellbeing. Our electronic controllers integrate real-time measurements to a shared-control assistive driving algorithm, based on a deep learning artificial intelligence training procedure. This leads to adjustments of wheelchair speed and acceleration obtained from the shared (user/AI-based) controller for better ride comfort and reduced injury risk.
Keywords: Maximum Transient Vibration Value (MTVV), Ride comfort assessment, Smart wheelchair, Artificial Intelligence shared-control algorithm.
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A Smart Posture Monitoring and Correction System for Wheelchair Users

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Background: Wheelchair users may experience discomfort and ulceration from continuous sitting. Seating pressure distribution is typically assessed using expensive multi-point measurement mats, not appropri-

ate for real-time posture assessment during everyday use. Existing solutions include cushions inflating and deflating alternate air chambers embedded in the cushion. These systems operate without user posture feedback, leading to further ulceration. To address this, we propose a smart monitoring system to continuously assess user posture and selectively adjust a cushion to alleviate pressure and potentially correct posture orientation. The proposed system measures pressure distribution and adaptively controls air pressure in the cushion to automatically re-adjust posture. This aims to reduce the need of support from carers and reduce ulcers risk and general ride discomfort caused by posture changes resulting from collisions or vibrations.

Method: First, we map pressure distribution to determine areas of high interface pressure by low cost force sensors (Force Sensitive Resistors – FSRs) placed on the seat. Two types of FSRs are used; one square (4.5 cm $\times$ 4.5 cm), and one disc-shaped (2 cm diameter), placed at seven locations on the seating area, two at the front, two at the back, one in each side, and one in the middle of a 5 $\times$ 5 grid on the 45 cm $\times$ 45 cm cushion. Five different posture inclinations were tested (wheelchair at horizontal surface): straight, right, left, forward, backward leaning. Participants were instructed to lean approximately 20 degrees from vertical. One further condition tested with the wheelchair at 10 degrees inclination (17% surface lateral rise). This represents riding on an inclined pathway (pavement drainage rise 2% to 5%). We tested two subjects representing approximately the minimum and maximum of mass and height for the wheelchair used: 1) mass 110 kgs, height 185 cm, 2) mass 50 kgs, height 165 cm. Tests were contacted on hard seating surface (no cushion) and on normal cushion. Each measurement lasted for 30 seconds taken as the mean of sampling at 500 ms intervals. Following pressure changes detected, posture was adjusted using air supply to four air chamber regions independently. Air pressure was measured and controlled electronically by pneumatic valves.

Key results: Compared to XSENSOR mat (benchmark baseline) both types of FSR sensors provide consistent measurements for different inclinations (std $\pm$ 1% mean value). Measuring pressure using a cushion substrate provides more reliable data (no sensor data failures). Also, for left, right leaning, pressure reduction in opposite side provided higher value indicators of corresponding inclination. Front and back sensors provided unreliable measurements due to differences in seating contact area resulting from footrest height. The centre of seating area sensor produced many failures (consistent with XSENSOR mat indicating low pressure at this location). Finally, small sensors (discs) gave higher rates of change (-45% to -50%) than larger FSRs (-22% to -38%).

Conclusion: Body posture or wheelchair inclination can be estimated reliably using disc shaped FSRs at appropriate wheelchair cushion locations. Measurements are proportional to corresponding inclinations and can be used to control our innovative electronic pressure control for air tube-based cushions to correct at least 12% of corresponding posture inclination, thus improving user ride comfort.

Keywords: Seating posture monitoring, Posture correction, Smart wheelchair.

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Special Thematic Session 16
AT2030: A New Approach

Globally, one in ten people who needs assistive products and services to maintain or improve their lives has access to them. This number is increasing whilst the gap between need and provision is growing.

At the Global Disability Summit two initiatives – AT2030 and ATscale. ATscale is a new global partnership for AT which aims to accelerate access to AT and AT2030 is the first programme of ATscale. AT2030 has been designed to be 'fast start' – it is an intentionally flexible and exploratory programme, designed to test 'what works' in getting life-changing Assistive Technology (AT) to the people that need it the most.

AT2030 is comprised of six programmes and our special session reports on key learnings and challenges from each programme. The six programmes are:

1. Coordinate evidence and research – is developing new models for return on investment and creating a market shaping framework methodology.
2. Spark Innovation – is creating an Innovation Hub in Kenya linked to a challenge fund and testing new innovations in low resource settings.
3. Drive availability & Affordability – is testing market shaping methodologies, creating market shaping tools and pilot test market interventions.
4. Open-up Market Access – is developing new models of integrated AT service provision.
5. Build Capacity and Participation – is working in informal settlements in the global South. Scoping community-led solutions to AT, researching community-led practice and inclusive approaches.

6. Support ATscale the Global AT Partnership.

We welcome debate on the future direction of AT2030 and ATscale.

Chair: *Cathy Holloway*

ATscale – Meeting the Global Need for AT Through an Innovative Cross-sector Partnership

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Background: Today, over 1 billion people need at least one form of assistive technology (AT), but 90% do not have access to the AT they require. The number of people who need AT is expected to grow to more than 2 billion people by 2050. Despite evidence and consensus around the huge unmet need for AT globally, research shows a wide range of systemic, underlying environmental challenges and cross-cutting factors contributing to the challenge in matching appropriate supply and demand for AT. While progress has been made in improving many aspects of AT delivery, the sector has been fragmented and under-resourced for some time. The environment is poised for change, as countries begin recognising the necessity of AT coverage to realise commitments to the Sustainable Development Goals and the UN Convention on the Rights of Persons with Disabilities. To uphold these commitments and influence the complex systems for AT access, a broad set of stakeholders across sectors is needed to invest in and coordinate a multi-faceted, systematic approach spanning market shaping, capacity development, and policy reform.

Method: In early 2018, consultations and initial landscape analyses were conducted to better understand the barriers and scope of challenges to increasing access to appropriate, affordable AT, particularly in low- and middle-income countries. This included review of past interventions and approaches, as well as discussion about current barriers observed throughout the AT ecosystem. Information gathered through this process was considered in a series of meetings and workshops to develop a framework for a new partnership model with the potential to address these gaps.

Key results: An understanding that transformational change requires market shaping approaches to address supply and demand-side barriers, supported by an enabling environment, emerged from the broad consultation and analysis. Building this enabling environment must include galvanising political will, mobilising resources, increasing awareness, addressing policy, and strengthening systems and service delivery. Accomplishing this requires a cross-sector partnership acting as a catalyst for change, amplifying existing work, and coordinating and mobilising global stakeholders. In July 2018, this vision was realised with the launch of ATscale, the Global Partnership for Assistive Technology, at the Global Disability Summit. Eleven organisations joined ATscale's Forming Committee with a goal of reaching 500 million more people with life-changing AT by 2030. ATscale has established its initial strategy and has set out to develop a long-term operating model. Several early interventions to support the ATscale strategy are being undertaken by AT2030, a UK aid funded programme.

Conclusion: This Partnership will enable partners working in distinct sectors to collaborate with a unified mission, facilitating complementary approaches, innovation, and capacity building. The coordinated approach of convening a broad range of leading stakeholders across sectors will increase access to affordable, appropriate, and high-quality AT products and services, leveraging current and past work to address the entire AT ecosystem. The initial work, including the strategy overview, already reflects diverse perspectives and the opportunity provided by a collective effort, supporting the global community to have an impact greater than the sum of its individual parts.

Keywords: ATscale, Cross-sector, Partnership, Access.

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Increasing Access to Assistive Technology by Addressing the Market Barriers: A Market Shaping Approach for Wheelchairs

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Background: Market barriers limit both supply and demand of appropriate AT in low- and middle income countries (LMICs). Market shaping aims to break the vicious cycle of low supply, low private investment, limited competition, and high prices that perpetuates low demand. Market shaping has proven successful in increasing access to global health products including vaccines and antiretrovirals, leading to hypothesize that these approaches could also be applied to AT markets. ATscale, the Global Partnership for AT, aims to mobilise global stakeholders to shape markets in line with a unified strategy. To inform this strategy, it is critical to identify specific interventions required to shape markets and overcome barriers. Wheelchairs are the first assistive technology undergoing analysis, which is being delivered by Clinton Health Access Initiative under the UK aid funded AT2030 programme. WHO estimates that 75 million people need an appropriate wheelchair and most lack access. The market for appropriate wheelchairs in LMICs is highly fragmented and characterized by limited government engagement, limited investment, and low willingness-to-pay and is dominated by cheaper, low quality wheelchairs failing to meet end-user needs. Non-governmental organizations (NGOs) have attempted to fill the need for context-appropriate wheelchairs, but market uptake is limited. These initial findings led ATscale and AT2030 partners to believe that market shaping could support increased access to appropriate wheelchairs.
Method: To develop a robust understanding of the market landscape and identify opportunities to increase access to appropriate wheelchairs, a mixed-methods approach is used including a grey literature review, market data analysis, key informant interviews, and site visits. The analysis outputs are captured in a market shaping strategy document that incorporates a market landscape, key barriers, and identification of market shaping objectives, recommended interventions and outcomes. The authors have sought input from experts, suppliers, and stakeholders throughout the drafting and stakeholders will provide feedback on proposed interventions through virtual roundtable discussions prior to finalization.
Key results: The process led to recommendations on marketing shaping interventions to increase access to wheelchairs. On the demand-side, incorporating proven models for provision in the health sector in line with WHO Guidelines may stimulate appropriate provision and increase predictable demand. Tools to support countries to develop roadmaps for integration around financing, policy, provision and procurement will be important enablers. Pooling resources though innovative financing, such as co-financing, may decrease fragmentation of resources available and catalyse demand. On the supply-side, the development and adoption of specifications and preferred product profiles (PPP) may strengthen procurement for context appropriate wheelchairs, decrease market fragmentation and increase market transparency. Mechanisms to secure a reliable supply for a range of affordable AT may require an approach combining technology transfer or licensing from manufacturers, regional distribution systems, and local assembly (rather than manufacturing).
Conclusion: This work provides evidence to inform ATscale's strategy and investments and will continue to inform the approach and reach of AT2030. Interventions may include additional evidence generation, development of tools to support decision-makers or piloting models of financing, provision or supply. The same process will be used for other priority AT.
Keywords: Market Shaping, Wheelchairs, Access.
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AT2030 – Exploring Novel Approaches to Addressing the Global Need for AT

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Background: It is well known that the provision of assistive technology (AT) is a 'wicked' problem and one

that requires new thinking to solve. AT2030 is a programme of investment which is part of a new global movement, to find new cross-sectoral approaches to AT provision and use. AT2030 was designed based on a scoping study into the barriers affecting AT provision. The scoping study had the objective of answering the following two questions:1) What are the barriers which prevent access to AT for the people who need it, with a focus on those living in low resource settings within the UK Department for International Development (DFID) priority Global South countries? 2) How should DFID, in partnership with others (including particularly other donors), best direct its interventions toward overcoming these barriers?

Method: The method used was flexible and iterative in nature. It sought to bring in expertise from across a diverse set of stakeholders and organisations. The emerging ideas were tested through stakeholder interviews and discussions and were refined though partner workshops and external events. The methodology was characterised by a participatory and consultative process, with clear objectives, and was both inclusive and transparent. This provided an opportunity to reflect on the applicability of evidence in different contexts and promoted dialogue among different types of stakeholders. Due to its rigour, flexibility and appropriateness in summarizing relevant features of complex datasets including different sources, thematic analysis was chosen as the analysis method for this scoping research.
In total 18 sets of field notes alongside transcripts of 23 semi-structured interviews were analysed. These data sources had been collected during meetings with stakeholders such as funding agencies, research partners and AT providers. Interviewees worked in different developing countries and were employed in various sectors including academia, industry and NGOs. These were supplemented with two deep-dive scoping exercises conducted in Kenya and Uganda. This corpus of data was analysed and coded using a hybrid deductive and inductive approach.

Key results: Our work reveals differing levels of AT market development across countries. However, the key barriers are common. Five broad areas to categorise barriers, facilitators and opportunities for improving AT access in developing countries were identified and prioritised according to the 5Ps model formulated by GATE: People, Products, Policies, Provision, Personnel.

Conclusion: We found the challenge of AT provision represents a complex web of market and systematic market failure, compounded by a lack of participation from the communities that have the best knowledge of the issues (users themselves). This results in a mismatch between supply and demand which affects almost a billion people. This makes AT access one of the most pressing problems facing the global health sector.

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Innovate Now: Creating an Assistive Technology Innovation Ecosystem in Nairobi

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Background: In Kenya there are at least 2 million people with disabilities and approximately 67% of them live below the poverty line. Being able to access appropriate assistive technology (ATs) is fundamental to ensuring people are able to improve their access to opportunities for education, livelihoods and life generally. Unfortunately, currently available ATs are often inadequate, too expensive and delivered through services which are unable to keep up with the demand. The Kenyan entrepreneurial spirit and technological creativity are renowned across the world. This creates a potential fertile ground for AT innovation where new technologies and disruptive service delivery systems are developed to increase access to AT, and to boost economic opportunities across the country. Although AT innovation could represent a lucrative opportunity for many tech entrepreneurs, only a few start-ups focus their efforts in the area. This is partially due to a lack of awareness, but it is also linked to the difficulty of bringing products to market in a field where ideas need to be tested with hard-to-reach populations and complex regulatory systems need to be navigated.

Method: Interviews with stakeholders were carried out to identify needs and difficulties of start-ups developing products for the AT market in low resource settings. Interviews were conducted with entrepreneurs, experts in the field of AT, accelerator and incubator managers and venture capitalists. Two scoping visits were also conducted to Kenya to map the innovation landscape and understand the gaps within the services currently provided to entrepreneurs. Negotiation meetings were held with potential partners to better define the role of NGOs, government agencies and the private sector within the innovation ecosystem.

Key results: Results from the interviews with stakeholders show that the barriers encountered by startups in the field of AT are many and varied. Some of the needs of AT startups are related to business planning, legal expertise marketing mentorship, which can be addressed by traditional incubators and accelerators programmes. However, AT startups also encounter difficulties in gaining access to environment where they can test and develop their products, receive feedback from people with disabilities and gather the strong evidence they need to secure funding from donors and venture capitalists. Reports from scoping visits demonstrate that Kenya has a wide network of incubators and accelerators that could support the activity of AT startups. However, these organizations are often disconnected from people with disabilities and NGOs who work on the ground, which limits the impact of the services they can provide.
Conclusion: To address the gap highlighted by our investigation, the Global Disability Innovation Hub thanks to the support from the UK Department for International development, has created the Innovate Now ecosystem which aims to support entrepreneurs throughout their journey and help their products to reach the market more quickly. The Innovate Now Ecosystem is funded through a network of partnerships involving government, private businesses, NGOs and academic institutions where each partner has a specific role and provides contextual support and expertise to new start-ups who have developed innovative ATs.
Keywords: Innovation Ecosystem, Assistive Technology, Start-up, Incubator.
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Moulding a New Prosthetic Service Delivery System with the Amparo Confidence Socket

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Background: Lower limb amputation is a major surgical procedure that can completely change a person's life. Thanks to lower limbs prosthesis, amputees often regain their independence, resuming their desired roles in family and social life. Unfortunately, many amputees who live in low and middle income countries do not have access to the prosthetic services that they need. Without an appropriate prosthesis, amputees often remain dependent on family and community and are unable to access basic rights such as food, shelter, education and work. One of the main factors responsible for the difficulty of providing appropriate lower limb prosthetics is the high cost associated with their fabrication. In turn, this is mainly linked to the need to rely on specialized health care workers and expensive workshop equipment for most of the manufacturing process. Generally, making a lower limb prosthetic is a highly individualised process and requires on average 8 hours of work time from the healthcare professional with two of these hours spent with the patient on two separate visits.
Method: Amparo Gmbh has developed a new thermoplastic pre-assembled socket that can be molded directly on the residual limb of the amputee, thus drastically reducing the time, tools and expertise needed to manufacture lower limb prosthesis. The pre-assembled socket is also fitted with the attachment point, allowing the technicians to easily connect the socket with the terminal part of the prosthesis. The low-temperature thermoplastic allows the socket to be remolded several times to accommodate changes in the residual limb which are common after amputation. Finally, the equipment needed to manufacture a lower limb prosthetic with the Amparo socket can easily be packed in a standard suitcase, making possible to adequately fit lower limb prosthesis within. To understand the benefits of the confidence socket we carried out observations of during socket fitting procedures and informal interviews with both prosthetic technicians and below the knee amputees who are currently using the product.
Key results: The socket has received positive reviews from both amputees and healthcare professionals. Technicians particularly appreciated the ease of use and how quickly they could fit the socket and test the prosthesis with their patients. Amputees praised the comfort of the socket and were impressed with the fact that the socket eliminates the need for multiple visits and the waiting time when modifications have to be made. Amparo is currently working with the Global Disability Innovation Hub and local partners to trial the thermoplastic socket in Kenya to assess the feasibility and acceptability of the new technology with the local workforce.
Conclusion: To reducing the cost, time and skills required to fit lower limb prosthetics. Its impact is potentially greater in low and middle income countries where shortage of human and material resources make

providing appropriate prosthesis a particularly complex issue.

Keywords: Lower Limb Prosthetics, Amputees, Prosthetic Technicians.

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Developing Tablet Audiometry for Screening Children's Hearing in Tanzania

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Background: WHO has estimated that there are around 466 million people worldwide that have a disabling hearing loss, and 34 million of these are children. The majority of children with hearing impairment live in low-income countries, and in Sub-Saharan countries most children with hearing impairment remain undiagnosed, untreated and without the provision of adequate services and devices. The current provision of hearing aids is inadequate across most low- and middle-income countries. For the individual child, hearing loss normally has a large impact on life because the loss of hearing affects the development of speech, language and cognitive skills. Public awareness and attitudes towards childhood disability in low- and middle-income countries are often poor, and may lead to social isolation, stigmatization and exclusion from education and employment. The objective of the research has been to develop new appropriate tools for screening children's hearing in local communities in low- and middle-income countries, and to assist children with hearing loss to attend school and participate in society. The research project specifically addresses the topic of Inclusive Education and the UN Sustainable Development Goals Nr 4 on Quality Education.
Method: A participatory research design and co-design process characterised by user involvement and iterative design processes were selected. The iterative process includes problem definition, identifying user needs, defining system specifications, developing technology, prototyping, testing and evaluation involving users and relevant stakeholders. The prototypes have been refined according to the knowledge gained in the testing, before passing onto a new iteration. Qualitative research methods have been applied for providing user needs and a better understanding of the situation for children with hearing impairments and include individual interviews, focus group interviews, questionnaires, field studies and observations involving children, parents, school teachers, hearing experts, authorities and NGOs.
Key results: A new tool for community-based screening of children's hearing has been developed. The screening tool have been tested at primary schools in Tanzania and the screening tool is based on the concept of gaming and consist of commercially available tablets, headphones and dedicated software developed by the project. The game-based tablet audiometry has been validated with reference to traditional audiometry and tested. 407 children in primary school in Tanzania have participated and been screened for hearing loss, measuring the hearing thresholds of 25 dB with tablet audiometry and traditional audiometry. The paper describes the development process and present the results from testing and validating the tablet audiometry at primary schools in Tanzania.
Conclusion: The new screening tools using game-based tablet audiometry has the potential of facilitating the development of local hearing services in low- and middle-income countries and screening children's hearing at local schools without expensive and specialised equipment. Special teachers and school teachers will do the screening. Awareness and identifying children with hearing impairments is the first step towards Inclusive Education and participation.

Keywords: Children with hearing mpairment, Hearing loss, AT in low-and middle-income countries, Tablet audiometry, Disability.

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Assistive Technology Services for School Children with Disabilities in Tanzania: The Role of NGOs and the Need for Intersectoral Coordinations

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Background: According to UN, less than 1% of school-aged children with a disability in Tanzania are enrolled in school. Tanzania developed an Inclusive Education Strategy to ensure equitable access to quality education for all. Tanzania has no national procedures to assess the needs of children before enrolment in school. District-level educational resource and assessment centres were suggested in 2013, including screening and referral for assistive technology (AT) provision. Yet, rehabilitation services and AT systems for children with impairments are poorly developed and often inaccessible or unaffordable in a country with 55 million inhabitants. The aim is to discuss how public-private collaboration, NGOs and intersectoral coordination may contribute in fulfilling children with disabilities' rights in education and health, rehabilitation and AT provision.
Method: The discussion is based on previous case-study research and recent data collected through multi-sited ethnographic fieldwork and visits in public and private rehabilitation- and education institutions and NGOs in rural/urban Tanzania since 2012, and experience-based knowledge. Methods included document and literature-review, participant observation and interviews of stakeholders in disability-related organizations and parent associations.
Key results: Public and private rehabilitation institutions providing AT have increased in number, in particular in urban areas with specialised hospitals, for-profit enterprises and not-for-profit NGOs. For the growing middle-class, advanced AT (for ex. cochlear implants) is available, or can be purchased abroad. Yet many children with disabilities (CWD) who live in rural areas may never access basic AT such as spectacles, crutches or wheelchairs. NGOs seem though to contribute significantly in rehabilitation and inclusive education. In three decades, Comprehensive Community Based Rehabilitation (CCBRT) has become Tanzania's largest provider of rehabilitation services, with a hospital, CBR units, AT production centres, and outreach throughout the country. As a social enterprise serving the most vulnerable, they collaborate across sectors, and invest in prevention, advocacy and training, promoting early identification and follow-up through innovative ICT and "ambassadors". Quality-services for children and the poor are increasingly financed by income generated through a private clinic.
In the special education sector, privatisation has increased the number of schools. However, in public schools, very few special education teachers, lack of appropriate resources and rare specialised assessment centres, with inadequate budgetary allocation, results in poor AT support. At the same time, some local and international NGOs collaborate with the Ministry of Education implementing district assessment centres, developing operational tools for identifying and documenting the needs of CWD, and providing and referring them for services.
Conclusion: In spite of policies affirming the right to education for all children in Tanzania, need-assessment and AT provision is still random, with rare public support to enable quality services. Some disability-NGOs apparently address children's special health- and education needs early, also in marginalized locations, increasing availability, accessibility and affordability of services, while investing in advocacy, community empowerment and competence building, mobilizing funding, and pursuing sustainability. Government commitment and national coordination of AT services across health-, education and social sectors, and public-private collaboration may promote a more equitable distribution of AT services, thus allowing education for all.
Keywords: children with disabilities, assistive technology systems, Tanzania, NGOs, inclusive education.
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Comprehensive Approach to Assistive Technology in Low-income Country: A Case Study of CRP Bangladesh

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Background: Assistive technologies (AT) encompass a wide range of technologies and devices that maintain and improve individual's functioning, independence and participation. Equal access to AT is included in the Convention on the Rights of Persons with Disabilities. WHO estimates that only 5%–15% of people who require AT in low- and middle-income countries have access to them, and this is true for Bangladesh as well. An estimated 1.6 million Bangladeshis need a wheelchair and 800,000 need an orthotic device. There are no facilities for large scale production of ATs, no official distribution system, no financial support for provision of AT for persons with disabilities, and no

planned approach to AT imports. Although imports increase AT availability, it is not known whether they are fitted properly and what kinds of consequences that may have on psychological, social and physical functioning. There are very few qualified rehabilitation professionals who are trained to prescribe individualized AT. Also, there are many environmental barriers that prevent participation of persons with disabilities. The Centre for the Rehabilitation of the Paralysed (CRP), a non-governmental organization, was established in 1979 to offer services to people with spinal cord injuries, children with cerebral palsy and adult neurology patients. It has grown from a four-bed unit to a 140-bed hospital with 12 regional rehabilitation centers, and an accredited academic branch that offers 11 diploma, bachelor's and master's programs in physiotherapy, occupational therapy, speech and language therapy, nursing, prosthetic and orthotics and rehabilitation science. This case study aims to contribute knowledge on AT production and distribution in Bangladesh, through examining promising CRP practices.

Method: This qualitative case study documents an approach to small scale production and distribution of AT. It presents the results of the content analysis of the relevant documents, articles, case studies and artifacts that were collected, reviewed, and complemented with observations at CRP Bangladesh in January 2019.

Key results: CRP has a comprehensive approach to AT production, distribution and follow-up for its patients in community and hospital settings. Over time, CRP has developed specialized units dedicated to production of various types of AT: appropriate paper technology, wheelchair and mobility devices workshops, special seating, hand therapy (splinting), and prosthetic and orthotics. CRP's approach to the provision of AT is based on principles of availability, affordability, adequacy, acceptability, appropriateness and quality (5As+Q). CRP increases AT availability by producing low cost and affordable devices. AT adequacy is ensured by individually fitting each device to meet user's needs, increasing the acceptance of the device by users. CRP ATs are made of locally available materials also considering the local environment and infrastructure. CRP AT services are of high quality, provided by qualified multidisciplinary rehabilitation teams with professionals trained at bachelor's level. They assess, prescribe devices and follow-up patients using telehealth, phone, or home visits to ensure modifications are done according to the changing needs of persons with disabilities.

Conclusion: The CRP's 5As+Q approach that ensures access to AT for its patients is context-sensitive and can be replicated and scaled up.

Keywords: Assistive technology, low income country, comprehensive approach, Centre for the Rehabilitation of the Paralysed, AT production in Bangladesh.

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Special Thematic Session 17
Care Robotics in Europe and Asia; A Multicultural Perspective

As ageing is a worldwide phenomenon international collaboration is increasingly important. This session highlights Care Robotics research and development in Asia and Europe. This is a fast developing field and the market for care robotics is expected to grow rapidly. In Asia as well as in Europe much research and development work is being done. The aim of this session is to present an overview of this work and to discuss differences and similarities between Europe and Asia, with a view on learning from each other and increasing the applicability of robotic solutions across continents. The focus is on care robot devices to enhance the quality of life of people with disabilities, elderly people and caregivers. During the session there will be sufficient time for discussion and input from the participants.

Chair: *Luc de Witte*

Care Robotics Development: A European Perspective

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Background: Care robotics is an area of assistive technology that promises much but has, as yet, delivered little. Excluding the specialist area of surgical robots, and notwithstanding the hype around robotics, it seems that few care robots are currently to be found in use on a day-to-day basis anywhere in the world. The most obvious reason for this would seem to be the relative immaturity of robot technology; however, there could be other causes: failings in the design and development processes, for instance, or structural deficiencies in the ecosystem that sustains the care robotics economy. The authors have probed the current state of the European

care robot development community and the causes of the apparent lack of practical results; this paper reports their findings.
Method: The authors conducted an internet-based analysis of care robotics companies worldwide, and performed an assessment of the market positioning of each and the state of its robot offerings based on current product and service availability, the evidence of peer-reviewed papers, its involvement in externally funded research programmes, and other supporting material. Focusing on the European experience, a workshop with experts in the field explored the issues around care robot applications, and a follow-up questionnaire was used to widen the scope to encompass other opinions.
Key results: The study confirmed the impression that, within Europe, care robots use is limited to, at best, standardized, repeated, localized, non-critical and low-risk tasks that require little robot intelligence or autonomy. In large part this is because the technology is not yet sophisticated enough; but also because the practical issues of introducing robots into complex care contexts and, to a lesser extent, safety, legal and regulatory concerns have not been satisfactorily addressed. However, it also revealed that there are structural weaknesses in a European care robotics ecosystem that relies heavily on public funding (at a national and supranational level) and is populated by micro and small enterprises, and university research departments. Perversely, this model serves to incentivize the development of robots that secure subsequent public funding rather than those that address real end-user requirements. Furthermore, the lack of appropriate instruments for assessing the holistic cost-effectiveness of care robots alleviates the 'evolutionary pressure' to develop better robots and robot services.
Conclusion: In general care robotics is (probably) the most challenging area of robotics: it involves long-term interactions with vulnerable people in complex, dynamic environments, and as such the apparent immaturity of the field is hardly surprising. It is clear that much effort, perhaps driven by more commercially focused domains, is still required to develop the fundamental robot and AI technology and to improve interfaces, reliability and safety. Moreover, we believe that the rate of development could be improved by the development of whole-lifecycle evaluation methodologies, by the greater involvement of potential service users in the design process, and by incentives that reward a greater willingness to risk exposing care robotics to real users.
Keywords: Artificial Intelligence, technology ecosystem, research and development, robotics.

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Planning Care Robot Project in Korea Based on User Centered Approach and its Future Direction

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Background: Korea faces an aging population, and care robot market is expected to grow rapidly. Though development and dissemination of care robot in Korea has not been prepared yet, some countries are already carrying out large-scaled national projects on care robots. The objective of this abstract is to document the iterative procedure used to identify needs, selection, and planning of care robot project in Korea based on user centered approach.
Method: Based on literature review, field observation of real space and people, in-depth & focus group interviews of various stakeholders, we identified the needs of care robot and selected care robot categories in Korea. Also we set up and held "Care Robot Network Forum ($n = 49$)" with various stakeholders including caregivers, care-receivers, researchers, companies, nursing homes and policy makers. Through this Forum, we carried out care robot project planning in Korea.
Key results: The results of the study in care robot project in Korea showed that there are 9 categories of requirements for care robots which is lifting, moving, changing position on the bed, toileting, eating, bathing, exercising, communication and smart monitoring. The five primary strategies of care robot projects are: 1) Intensive investment according to matching needs and technology for care robot; 2) Achievement through translational research; 3) Realization of smart care through 4th industrial revolution technology; 4) Personal-centered research with stakeholders; 5) Building a care robot ecosystem. Moreover, we need specific steps for care robot project in Korea. 1) Planning 2) Development of care robotic devices 3) Translation Research 4) Development of service model 5) Dissemination.
Conclusion: We identified the needs & selections required and planned the care robot project in Korea through this study based on user centered approach. Through this research project, we have started the first

period of Korea Caring Robot Project, which will be proceeded for four years from 2019. It is expected that joint research on the need for care robot and R&D direction considering various cultural differences will be needed in the future.

Keywords: Care Robot, Plan, Aging, Disability.

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What Should be Considered when Developing Care robots According to their Types?

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Background: The care robot project in Korea started in 2019. It is important to predict and prepare for the demands of the care robots. Based on 4P (public, private, people, partnership) approach, a questionnaire survey was conducted to identify the caring needs and consideration on the development of care robots.

Method: The participants ($n = 114$) of the survey are composed of public section ($n = 21$; policy maker, nursing home owner), private section ($n = 40$; company, researcher), informal caregiver ($n = 32$; family member) and care-receiver ($n = 21$) in Korea. The survey was conducted through online, using a survey tool called Google Survey from Oct 15th to Dec 16th, 2018. The online survey, composed primarily of checking boxes and comment fields, consisted of 38 questions. The data was analyzed through MS office excel and atlas.ti 8.0.

Key results: The results of the studies showed that the group with the greatest need for care robots is the informal caregiver group. Barriers in introducing care robot to the field include safety issues, clinical trials, field demonstration, and public benefits. For each kind of care robots, the important considerations for technology development were different; ceiling typed lift (current environment friendly device), exo-skeleton typed lift (user friendly), moving (safety), changing position on the bed (customized), toileting (hygiene), eating (customized), bathing (user friendly), exercising (customized), communication (Artificial Intelligence technology) and smart monitoring (Information).

Conclusion: The purpose of this study is to investigate the difficulty of caring and consideration of the development of care robots throughout the four groups. Through this study, we found that the main target of care robot is the caregiver. In addition, it was found that the priorities of consideration in the technology development were different according to the types of care robots. In order to supplement the limitations of this study (small scale, online questionnaire), we need to perform usability test, user experience and technology demand analysis in the future for care robots. It is expected that this research will help to set the direction of care robot project in Korea.

Keywords: Care robots, Questionnaire survey, Caregiver, Care robot project.

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Care Robotics in Europe and Asia; A Multicultural Perspective

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Background: Service robots have the potential to support older adults with executing problematic daily activities in order to maintain their independent living. However, stereotypes often suggest that older adults tend to be less open to the idea of living with a robot. Several multi-country studies that were conducted during the ACCOMPANY (Acceptable robotiCs COMPanions for AgeiNg Years) project provide insight in the acceptability of service robots by potential users in three countries (i.e. older adults, informal caregivers and professional caregivers) and their view on how a service robot should behave in a socially acceptable manner when interacting with potential users (i.e. the preferred characteristics of such a service robot).

Method: An existing service robot, the Care-O-bot 3, and different scenarios developed by the ACCOMPANY consortium were used as concrete cases in the different studies. These were discussed and analyzed during different focus group sessions with older adults, informal caregivers and professional caregivers in the Netherlands ($n = 97$), France ($n = 173$) and the United Kingdom ($n = 62$). During these focus group sessions various topics were explored. Detailed summaries of the qualitative results of the focus groups for each country were composed from audio recordings.

Key results: The results of the studies in the ACCOMPANY project showed that older adults in all three

countries are open to the idea of having a service robot supporting them in their daily life. It was even found that the older adults had a more positive attitude towards robots than their caregivers. Participants from all three countries agreed that a service robot should always have to obey the user. All participants also wished and often even expected that a service robot could be customized to the needs, wishes and preferences of each individual user. However, no major differences could be found in the views recorded among the participants of the three different countries. There were some small differences, for example: in France the participants mentioned more issues concerning the coordination of care and the role a service robot could play to improve this, while this was mentioned less in the Netherlands and the United Kingdom.
Conclusion: Only small differences could be found in the views recorded among the participants of the three different countries. However, this does not imply that there are no differences in the perception of care robots in Europe as the participants agreed that one size does not fit all; the robot has to respond to individual preferences. This makes the development of service robots complex as it has to deal with variety between different individual users (e.g. their personal preferences and home environments). In order for a service robot to do this in an acceptable manner it would require a high level of intelligence, a level that is currently not possible.
Keywords: Service robots, older adults.
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Special Thematic Session 18
Social Robotics for Assistive Technology

Social robots in the context of assistive technology are specifically designed for social interaction with humans. Such approach plays an important role with respect to health and psychological wellbeing of those that need assistance. Assistive social robots are demonstrated to be useful in wide range of assistance from robotic therapies for children to eldercare. Two fundamental reasons are at the basis of the success of this approach: a functional and an affective motivation. Such robots are developed to function as an easy-to-interpret and immediate interface to digital technology, and, at the same time, to help increase the quality of life by providing companionship. However, no comprehensive review is yet performed to investigate the effectiveness of such assistive social robots in the care. Therefore, we systematically reviewed some successful stories in social robotics for assistive technology and highlight the effects of assistive social robots for humans that need assistance.
Chairs: *Francesco Rea and Riccardo Magni*

Humanoid Robots: Advantages of Social Robots in the Assistance of Elders

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Background: In our research, convinced by incontrovertible evidences we propose different assistive technologies based on the proactive intervention of humanoid robots. The humanoid robots and their easy-to-interpret behaviors give the opportunity to promote acceptable assistance. Further the humanoid robot if correctly designed is more likely to be accepted as companion in the activities of daily living. Our key hypothesis is that the acceptance of robot companion has a direct and positive outcome in the assistance.
Method: With a multidisciplinary group of researchers addressing the rehabilitation of ageing individuals with mild cognitive impairment, we proposed robotic technology that proactively assist and promotes cognitive rehabilitation.
Key results: Key result is that it is more complicated to convince the traditional health care system of the benefit of the proposed technology with respect to the ageing individuals. They accept the novelty of robotic assistant more happily than predicted. The reason behind such high degree of acceptability stands in the possibility of interfacing with the technology through a companion that interacts according with known social rules.
Conclusion: The take home message is that in social robotics for assistance is important to involve the end-user user in the design in order to understand their social needs. Thanks to such understanding, the assistance can be enriched with a social dimension that promotes the level of acceptability of the technology. In the near future such interesting consideration will be proposed to partnership of interested stakeholders in the field of assistive technology.
Keywords: Human Robot Interaction, Assistive Technology, Ageing Population, Social Robotics, Humanoid Robotics.

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A Communication and Monitoring Robot System for Older People Living Alone

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Background: The number of older people living alone is dramatically increasing in Japan which in turn has led to the rise in the number of solitary deaths. This has become a disturbing social problem. Therefore, the importance of attentively monitoring older people who are living alone has recently been acknowledged. Currently, taking care and the monitoring of older people is undertaken by humans. However, due to the rapidly decreasing birth rate in Japan leading to a reduction in the Japanese labor force in the very near future, the number of care staff for older people will likely decrease. As a result, reducing the burden and work of care staff is urgently required. Therefore, we propose a robot system to assist and reduce care-staff workloads e.g. by monitoring and improving the quality of care. Our proposed system is mainly for the use of care staff of a community-based integrated care system in local communities.
Method: We have developed a communication robot system – a physical robot for older people, which utilizes the cloud network, as well as having a terminal for monitoring older people. The robots are able to speak with the older people, and can communicate local community information such as news, give daily routine cues, hold casual conversations and so forth. The user's speech is converted to plain text and an appropriate response message is found from the conversation database on the server (Cloud). The probability of the response message is calculated using Word2Vec. The robot also has physical motion functions and is installed with a three degrees of freedom motorized mechanism. The terminal for the person monitoring uses a web browser as a web page and can monitor their activity through the data from the robot. In consideration of ethical aspects, we have made it possible to monitor only simple activity records e.g. talk time, the number of counts by the human motion sensor and so forth. Additionally, the robot has the function of enabling it to make an emergency call and the monitoring persons can send messages to the robot and in turn the robot can convey these messages to the older person. Finally, a communication log is compiled and it will be analyzed and then used to evaluate the older person's activity levels.
Key results: A Communication robot system for older people who live alone has been developed to monitor, communicate and collect their activity data. Care staff belonging to the community-based integrated care system can monitor the older people through the robot. The robot, it's functions and the design of the terminal web page were checked by occupational therapists who are familiar with taking care of older people especially those with dementia. This advanced system has obtained positive evaluations from occupational therapists.
Conclusion: As a result of developing the communication robot system for older people who live alone, the next step is to actually place the robots into single, older people's homes.
Keywords: Older People Living Alone, Communication and Monitoring, Robot.
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Robot-assistive Joint Attention Training in Autism Spectrum Disorders

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Background: The advent of new technologies allows researchers to investigate subtle features of the human behavior, by dissecting it and by creating well controlled experimental paradigms. A systematic investigation of such features is desirable in order to facilitate the interaction between humans and artificial agents. Although numerous authors demonstrated the efficacy of assistive technologies in neurodevelopmental disorders, sample sizes and methods of previous studies determined dubious results. Based on previous literature results and limitations, we defined a robot-assistive joint attention training tailored to autism spectrum disorder. The training consists in a spatial attention game with the robot Cozmo, which interacts with objects lo-

cated in front of it, stimulating the child's attention. Activities include a 15 minutes interactions with the robot during rehabilitation sessions, and will be carried out twice a week for five weeks.

Method: To test the efficacy of the planned training, 38 children (29 males, age ranging from 3 to 7) and their families were involved in the activities. Prior to the activities, children diagnosis was re-assessed using the ADOS 2 and ESCS, to determine their functionality level. Clinicians and families involved in the protocol were evaluated in terms of implicit and explicit attitudes towards robots, using and Implicit association test (IAT) combined with self-report questionnaires (i.e. NARS, ROSAS, FSQ). An additional self-report questionnaire was created ad-hoc in order to assess the familiarity and the previous experience with the robots along with the expectancies toward robotics (FITTER questionnaire). We trained clinicians to autonomously control the activity of the robot. 8 children were excluded from the study after a two-week familiarization phase, due either to a lack of interest or impossibility to carry out the activities. In order to allow all children to interact with the robot, a cross-over design was adopted. The training is currently ongoing with 30 children.

Key results: Preliminary results based on questionnaires administered to clinicians revealed a positive correlation between age and discomfort perceived towards the robots ($r = 0.50$, $p = 0.03$), anxiety towards robots ($r = 0.50$, $p = 0.03$) and reluctance towards interaction with robots ($r = 0.49$, $p = 0.04$). Previous experience with the robots negatively correlated with perceived warmth during the interaction ($r = -0.48$, $p = 0.04$). Reaction times collected with IAT revealed a negative association between robots and mentalistic concepts ($F = 157.45$, $p < 0.001$). Qualitative reports collected from the clinicians after the familiarization phase revealed a positive attitude towards the robot from the vast majority of the children. Children from all functioning levels seem to be able to understand the task, providing either verbal or non-verbal response. Post-training improvements will be assessed with the ESCS and ADOS 2.

Conclusion: Preliminary data suggest the existence of a positive attitude towards robots both in the children and in the young clinicians involved in the activities. Despite the initial skepticism, the entire sample of clinicians reported a positive experience with the robot after the familiarization weeks. We expect the effects detected from the self-report questionnaires to change after the training, due to the increase in the familiarity and expertise with assistive robotics.

Keywords: Assistive Robotics, Human-Robot Interaction, Autism, Social Cognition.

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Promoting the Use of Social Robots to Engage Students with Special Education Needs (SEN): Development of a Teacher-friendly App

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Background: The use of social robots with students with special education needs (SEN) is gaining increased attention within research due to their ability to engage students in social activities. Anthropomorphic robots, for example, have been proposed as ideal social mediators encouraging engagement within student groups that find social skills difficult to develop, and by extension find traditional learning methods difficult. In addition, recent investigations have begun to show a positive impact that robots could have within SEN teaching through encouraging engagement with learning activities. Technological competence and lack of easy to use robotic platforms, however, may make the use of the social robots for SEN students difficult, increasing the likelihood that the robots will not be used in the future by potential stakeholders. In this view, the present contribution reports on the development of an app to facilitate the development of robot-based educational activities targeting SEN students and promote the use of social robots in mainstream schools.

Method: The design and development of the app followed a Living Lab (LL) approach. LL is a user-driven open innovation ecosystem which enables users to take an active part in the research, development and innovation process. In this study, a permanent panel of 5 SEN teachers were involved in the conceptualization and design of the app aimed at controlling a humanoid robot (Aldebaran NAO humanoid robot). Iterative group discussions between the SEN teachers and the development team were organized to develop a first working prototype interface running on an Apple iPad®. The prototype was pilot-tested with a student with Down Syndrome (age 8 years) and mild intellectual disability using a AB case study design. Activities proposed with and without the social robot tapped language and math skills.

Key results: The app developed allows SEN teachers to control the humanoid robot and activate learning activities without the need to connect further devices as in already available NAO controllers. The app was considered usable and easy to understand, even if further refinements are needed to ease the use of the application. The results from the case study revealed comparable results between the traditional and robot-based approach to learning, thus suggesting that the introduction of a humanoid robot is not detrimental for student's learning achievement. On the contrary, according to the opinions of the teachers, it may open novel learning scenarios.

Conclusion: Social robots are increasingly used not only 'in education' (e.g. as a support to teach technical skills), but 'for education' – that is, as a medium to teach curricular subjects. In this view, robot-mediated education is opening new learning scenarios in which the student learns from – or together with – a robot that is capable of asking questions, providing feedback and suggestions, and in general to engage the student in social interactions. More research is warranted to explore whether the use of social robots may improve inclusion in education of SEN students usually at risk of marginalization.

Keywords: Social Robots, Special Education, Intellectual Disabilities.

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Technology and Disability 31 (2019) S109–S123
DOI 10.3233/TAD-190005
IOS Press

Part 2: Aging

Reducing Health Disparities in Older People through Assistive Technology

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Background: Health disparities are preventable differences in the opportunities to achieve optimal health that are experienced by socially disadvantaged populations. Older people are at a greater risk of experiencing health disparities than younger people. Technology has great potential for reducing disparities, particularly as we improve our understanding of the role it plays in social processes of aging. The next generation of assistive technologies should be informed by research on how best to ensure that they can be easily and effectively integrated with educational, health and social services, and that their benefits can be distributed equitably across all populations of persons who are ageing.
Method: This author conducted a scoping review of the literature on the relationship between assistive technology and social determinants of healthy ageing. A search was conducted for journal publications of original research studies and reviews in the English language. Search engines included PubMed (Medline), CINAHL (Ebsco), PsycINFO and Web of Science, using the following parameters: aging population (including elderly and seniors); assistive technology (including communication technology and health technology); health disparities (including health inequities, social isolation, and social determinants of health).
Key results: Two social constructs are central to social relationships and physical health in ageing: social support and social integration. Social support refers to a social network's provision of psychological and material resources intended to benefit an individual's ability to cope with stress. Social integration is defined as participation in a broad range of social relationships. It is a multidimensional construct thought to include a behavioral component and a cognitive component. Assistive technology (AT) is capable of influencing both of these components. Precisely how AT influences social support and social integration, and thereby affects healthy ageing, is unknown. Assistive technology, such as information and communication technologies (ICTs) are promising technologies for improving for social support and social integration because they emphasize intervention in natural social networks. They are a means of making changes in social relationships that one can rely on months and years beyond the period when they are first introduced to an older person. ICTs can be used also to increase the availability of social support within existing social networks by helping to improve individual social skills or by building stronger ties to existing network members. They increase social integration by creating and nurturing close and peripheral ties between an older person and their community.
Conclusion: Assistive technology (AT) has the potential to intervene successfully in all critical areas of influence on social connectedness provided that three essential spheres of activity are optimally interacting: (1) Technology – the technology can demonstrably produce the effects on social support and social integration described above; (2) Services – educational, health, and social services are available to help an older person exploit these functional benefits; (3) Policy - subpopulations of older persons (e.g. cultural or linguistic minorities, ID and DD populations who are ageing) are not excluded from the provision of AT supports and services are treated equitably.
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Assistive Social Care Technologies for Older People: Let's Talk More About This

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ISSN 1055-4181/19/$35.00

Background: Health and social care are facing unprecedented challenges due to the changing patterns of disease, the demanding expectations of service users, financial restrictions and an ever increasing ageing population. The effect of these challenges are observed in the increases in demand for, and use of, health and social care, the cost of caring and the need for more qualified carers. Assistive technologies, in particular digital technologies, are being heralded as part of the solution to provide sustainable social care services.
Human relationships are paramount in social care across the life course and are important for the care workforce as giving care often has value for the care giver. Protecting autonomy and upholding the right to human relationships is integral to treating older social care users with dignity. If assistive technologies are to be of benefit to future generations of people in need of assistance we posit that a broader community discussion about the value, worth and place of assistive technologies in social care is required to help inform and to realize policy ambitions and to meet the social care needs of older adults. The aim of this research was therefore to identify key questions for future dialogue.
Method: A systematic literature search with a narrative synthesis was undertaken to identify potential research questions for debate. Using free text terms, synonyms and subject headings relating to assistive technology and social care, a systematic search of articles published in English between January 2000 and December 2018 were sourced from Medline (EBSCO), CINAHL (EBSCO), PsychINFO (ProQuest), Social Science Premium Collection (ProQuest), British Library Social Welfare Portal and the EThOS databases. Policy documents and discussion pieces on digital technology use in social care were also reviewed as they demonstrate emergent thinking around societal, ethical and moral issues. Record titles and abstracts were assessed by research team members. After removing duplicates, 2473 records were identified for review. Sixty-seven full-text copies of items thought to meet the review inclusion criteria were obtained and assessed against these criteria. Forty-two items fulfilled the inclusion criteria. Eligibility criteria were: items had to be written in English and had to describe and/or report on the use of assistive technology in a social care setting for older people. Disagreements were resolved by consensus within the research team.
Key results: Three distinct questions emerged from the data for broader discussion: (1) What are the implications of placing elders in a position where they are 'cared for' by technology devices? (2) If assistive care technologies fail to provide assistance as good as people, is it right that limited resources are invested in devices instead of the social care workforce? (3) Whose interests are being serviced: the people who are caring, the people who are being cared for or the market?
Conclusion: To ensure that the promises and benefits of assistive technologies in social care are realized a clearer understanding of the importance of relational care and people's interdependence is required by engaging a wider audience in the discussion.
Keywords: Assistive technology, Social care, Older people, Human relationships.
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Experiences with the Use of Welfare Technologies for Elderly Persons

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Background: Western societies are facing challenges in health care due to the increasing number of elderly persons, persons with dementia and persons with chronic diseases. The use of technology is expected to support active aging and independent living and to reduce the need for specialised care at nursing homes. The term 'welfare technology' refer to technologies that may support persons safety, freedom and active aging, while maintaining independence and autonomy at home and comprises terms such as assistive technology, care technologies, telecare and technologies for health monitoring and medication support. The objectives of the research studies are to document how elderly persons, persons with dementia and persons with chronic diseases, and their caregivers experience the use of safety alarms, localisation technologies and medication dispensers. The article describes and discusses how the use of these technologies contributes to physical activity, safety, freedom and independent living.
Method: Action research and a participatory innovative design were chosen in order to understand underlying causes and enabling future improvement and development. The inclusion criteria were elderly persons living at home aiming for independent and active living, persons experiencing orientational challenges or persons receiving medical assistance from home-

based services. Professional caregivers assessed each individual users' needs before inclusion and selecting the appropriate welfare technology. Informed consent was obtained from the participants or by proxy from their relatives or professional caregivers. The study included 71 participants using Mobile Safety Alarms, 208 participants using Localisation Technology (GPS) and 49 participants using Medication Dispensers. It was a four-year longitudinal study.

Key results: For users of Mobile Safety alarms, most users (97%) reported that carrying the alarm and knowing that they might activate the alarm-button and call for help, if necessary, made them feel safe and they could continue their outdoor activities. About half of the users (52%) reported that the alarm gave them more freedom. Safety and the users' freedom to walk outdoor alone were also the most frequently reported impacts of using the GPS (90%), and this increased the users' autonomy and physical activity. Most relatives and professional caregivers reported that they felt safe and less anxious, because the GPS enabled them to locate and find the user, if necessary, and possibly avoid further escalation and emergency situations. 89% of the users reported that the medicine dispenser increased their sense of mastery and independence enabling self-management of medications. More than one-third (39%) of the users of dispenser, reported increased freedom and mobility. The dispensers significantly reduced the number of home visits by professional caregivers to half of the users.

Conclusion: The studies demonstrate that welfare technologies contribute to maintaining physical activity, safety, freedom and independent living for elderly people, persons with dementia and persons with chronic diseases. These technologies facilitated the user's ability to continue living independent at home, and welfare technologies may have the potential to delay the need for transfer to nursing homes. Careful assessment of each users and close collaboration among users, relatives and professional caregivers were reported to be a prerequisite for successful implementation.

Keywords: AT for elderly persons, AT for persons with dementia, assistive technology, welfare technology, mobile safety alarm, localisation technology, GPS, active aging.

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Assistive Products Use Among Oldest-Old People in Japan: Differences in Personal Attributes and Living Situation

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Background: Improvements in healthcare and lifestyles have allowed more people to live longer than ever. Japan, for example, has approximately 67,000 centenarians – the highest ratio per population in the world. Increasing age, however, is associated with increase in frailty, cognitive decline, chronic illness, and other impairments, and the use of assistive products (AP) becomes essential to live comfortably and autonomously in one's home. With the number of older people worldwide forecast to increase substantially, the global demand for AP is sure to increase. The use of AP can reduce the effects of several types of impairment, allowing older people to live more comfortably at home and remain active and engaged members of society. The very old population of Japan offers a unique source of information about the use of AP later in life. In this study, we will conduct a survey of non-institutionalized individuals, 90 years old and above, about their experiences with AP. The aim is to provide important insights to service providers in Japan, and globally, about strategies for the optimal provision of AP to older populations.

Method: Self-written or amanuensis questionnaires were posted to 4,530 people (90+ years) from the Kashiwa City resident basic ledger. We analyzed 1,602 valid responses (35.4%). The mean age was 92.8 $\pm$ 2.8 years old (484 males and 1,045 females); 45 persons were centenarians. The survey items are as follows: (1) age, gender, person living with, etc.; (2) liv-

ing functions (level of nursing care needed, IADL etc.); (3) services in use (support services, AP, etc.); and (4) inconvenience in daily life (free description). This research was conducted with the approval of the WHO and the ethics review committee of each affiliated institution.

Key results: Living situation was as follows: living alone (17%), living with spouse (11%), living with other family members etc. (50%), and living in facilities (22%); 67% of respondents received some national care support services, and 1,574 people (98.3%) are using some kind of AP. The utilization rates of dentures (76.2%), eyeglasses (64.2%), handrails (41.9%), and cane (41.0%) are high rate. There were also users of multiple AP (10+ types). Differences were found depending on AP, such as a wheelchair, which increases the utilization rate due to aging, and other AP, which decrease (hearing aid and walker). There was also a gender difference, and the utilization rate of walking AP was significantly higher for women. In addition, the usage rate of information AP for personal computers and smartphones was significantly higher for males. After further analysis to determine the reasons for these gender differences, we found that oldest-old females tended to have lower mobility than their male counterparts resulting in the higher need for walking AP.

Conclusion: The diversity of living conditions of elderly people including AP, nursing care services, and expert support was revealed. Additionally, the utilization of AP has revealed the fact that various items such as gender differences, degree of need for care, IADL, living together, etc., are involved.

Acknowledgement: This research was supported by the World Health Organization Centre for Health Development (WHO Kobe Centre – WKC: K18005).

Keywords: Assistive Product, Oldest-Old, Questionnaire Survey.

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"Preferred" Light Color in Home Lighting Interventions for People with Age-related Macular Degeneration (ARDM)

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Background: The level of brightness in the environment (lux) has a significant impact on the visual potential for people with visual impairments, but little is known about the impact of light colors (Kelvin). Only one descriptive study investigated the effect of light colors on reading performance ($n = 107$). It revealed better near-vision, smaller readable character size, and increased reading speed when using a magnifying glass with the preferred color temperature (2700K-4500K-6500K). Also, no publication was found to study the effect of ambient light colors on visual comfort. Our **research question** focused on the evaluation of the preferred choice of ambient lighting color tested with a near-vision assessment in clinic and by using standardized tools to evaluate the impacts at home for people with age-related macular degeneration (ARMD).

Method: An explanatory quasi-experimental design was proposed with 4 evaluation times and 3 interventions. A sample of 10 ARMD patients with visual acuity between 6/21 and 6/48 was recruited within the visual impairment program. The intervention lasted between 8 to 10 weeks for each patient and involved two visual impairment rehabilitation specialists. Evaluations were done with the Minnesota Low-Vision Reading Test (MN Read), the International Reading Speed Texts (IReST) the visual comfort scale (0–10), a digital Lux Meter-LX1330B and the Home environment lighting assessment (HELA). During clinical interventions the following instruments were used : the LuxIQ (4500K-5000K-6500K), magnifying glasses (diopters-10-12-16-20-24-28-39-40), and standing models (Eschenbach®-Optelec®-Schweizer®). Home lighting interventions consisted of: addition/modification of light bulbs (fluocompact-DEL-incandescent), rearrangement of lamps and glare reduction.

Key results: Six women and one man of 83 ± 11 years old with ARDM completed the experiment. In all cases, the use of the LuxIQ and illuminating magnifying glasses showed positive impacts in near vision to increase reading speed (49 to 58 words/min.) and visual comfort (5/10 to 8/10). It also shows positive

impacts in ambient vision after lightning interventions with preferred color in kitchen ($n = 3$), living room ($n = 3$) and office ($n = 1$). The level of ambient lighting at home was highly increased in all cases (249 to 1295 lux). HELA satisfaction also increased (3/10 to 8/10). In all cases, the preferred light color chosen in near vision was the same as the one used for ambient lighting. The cold color (5000–6500 K) was chosen 5 times and once for the warm color (2700–3500 K) and the white color (3500–4000 K).

Conclusion: Our preliminary results should have an impact on visual impaired rehabilitation. So far, we have demonstrated that by relying on the "visual" aspect of color (cold, white and warm) and not just the selected Kelvin, the color of light is transferable from the near vision to the ambient lighting vision in a chosen room. The color of the "cold" light temperature seems to be the preferred color of light in rooms where activities require precision. It would be interesting to test if the chosen temperature color (cold $\pm$ 5000 K) remained the same in a room designed for relaxing or resting activities. A multi-centric study could be a solution to realise more meaningful results at statistical level.

Keywords: Low vision, Light color, Home intervention (kitchen), Reading

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Stay@home with Dementia: From Needs Assessment to Assistive Technology

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Background: The number of patients with dementia living at home (about 70%) is still increasing. Assisted technology (AT) can support patients with dementia and their caregivers in daily life, to improve independence and safety. Despite the supply of AT, the use of AT in daily practice is only limited. One of the reasons is the fact that most AT is not adapted to the needs of persons with dementia. This study aims to investigate the specific needs of persons with dementia and their (in)formal caregivers in relation with AT and aging in place and to translate these needs into functional requirements.

Method used: To investigate the most important problems patients with dementia experience, patients ($n = 18$), informal caregivers ($n = 72$) and healthcare professionals ($n = 93$) filled in the FINAH and Amsterdamse IADL questionnaire. Qualitative research using focus groups and semi-structured interviews with 6 informal caregivers and 20 healthcare professionals, provided detailed information about the problem activities, their barriers and requirements for AT.

Key results: Based on the questionnaires and the focus groups, the 10 most important problem activities included: using appliances (e.g. household appliances, TV remote, telephone), disorientation (in time/structure of the day and regarding location), household activities (e.g. preparing meals, doing groceries, doing the laundry), administration (e.g. making payments, fill in forms, keep an appointment), personal care (e.g. washing oneself, toileting), taking medicines, emotions and behaviour (e.g. being depressed, disinhibition, fear, aggression), social contacts/participation and taking care of their own health. Barriers within these problem activities were in the following categories: insight/perception, structure, habits, behaviour/emotions, disorientation, complexity, recognition, preservation of independence, forgetfulness, learning new things, safety, not performing, social participation, co-morbidity, professional care and distraction. These barriers were translated into functional requirements of assistive technology.

Example:

Problem activity: using appliances (TV remote)

One of the barriers: complexity, i.e. too many buttons, too many different remote controls, too many options/functionalities, difficult operation.

Functional requirements: use limited number of buttons, reduce the number of steps to be taken to a minimum to operate the remote, make the remote adaptable to individual needs, make it impossible to disorganize the apparatus.

Additionally, some general requirements for assisted technology for persons with dementia were formulated in the following categories: Usage (e.g. user-friendliness, working autonomously, durability/ sustainability, easily accessible, reliability), design (e.g. recognizable, (un)conspicuous, neutral, visual, integrated), flexibility (e.g. tailor-made, adaptable to stage of dementia, suitable for home situation), aimed effect (e.g. safety, independence, reassurance, burden informal caregivers, social participation, communication), privacy and security (e.g. data security, privacy), juristically, financial (e.g. price, leasing possibilities)

and implementation (e.g. practicing with AT, timing, role (informal) caregiver, requirements home).
Conclusion: This exploratory study gives an overview of the most important problem activities for patients with dementia, the barriers within these activities and the requirements for assistive technology. The results were reported to companies specialized in assistive technology to support user-centred-design. In the second phase of this study, companies and healthcare professionals are working together in cocreation to develop/adapt products to create a user-centred solution for a problem activity identified in this study.
Keywords: Assistive technology, dementia, needs assessment
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CRDL – Interactive Technology Eliciting Engagement in Elderly People with Dementia

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Background: People with an advanced stage of dementia encounter problems with communication and verbal interaction, leading to a decrease in participation and social isolation. CRDL (Cradle) is an interactive instrument, specifically developed for people with dementia to stimulate communication and social interaction. Based on different types of touch, CRDL produces sounds. Research on the effects of CRDL to stimulate engagement is lacking. The research questions of this study were as follows:

1. Which interventions using CRDL may contribute to the stimulation of engagement for people with dementia?
2. What are the effects of these interventions in promoting engagement in people with dementia?

Method: The study consisted of two phases using a mixed-methods design. First, two interventions with CRDL aiming at the promotion of engagement were developed based on results of semi-structured individual interviews with 9 professionals and a brainstorm session with 6 professionals from elderly care organizations in the Netherlands. Second, the interventions were tested in daily practice in two nursing homes with 30 clients following an ABB-design; phase A includes one intervention session without CRDL; phase B (B1 and B2) includes interventions with CRDL. The primary outcome 'engagement' was measured with the Positive Response Schedule (PRS), an instrument developed to score engagement based on video-observations. Moreover, interviews with participating professionals were conducted to evaluate experiences of using CRDL. PRS data were analyzed using the Wilcoxon signed ranked test by comparing scores on the individual items between sessions A-B1 and A-B2.
Key results: The two interventions developed were 1) 'influencing behaviour' and 2) 'promotion of social interaction'. The procedure on how to perform the interventions was described in a manual. In phase 2 of the study 30 clients with severe dementia (22 female, 8 male) and six care professionals of two elderly care organizations participated. The professionals could choose intervention 1 or 2. For 10 clients intervention 1 was selected and for 20 clients intervention 2. In the A-phase interventions without CRDL were used. For the intervention 'influencing behaviour' positive effects were found compared to interventions without CRDL on four items of the PRS, i.e. deliberate body movement (B1-A $p = 0.051$ and B2-A $p = 0.025$), deliberate head movement (B1-A $p = 0.017$), focus on environment (B1-A $p = 0.011$ and B2-A $p = 0.091$) and engagement (B1-A $p = 0.059$ and B2-A $p = 0.097$). No differences were found on the PRS items for the intervention 'promotion of social interaction'. Professionals all reported positive experiences of using CRDL and expressed their willingness to proceed working with CRDL.
Conclusion: The study resulted in two meaningful interventions for application of CRDL in dementia care practice and gave positive indications for effects of CRDL to stimulate engagement. Future research on the effects of these and other CRDL interventions among a larger population and in other target populations, such as people with intellectual disabilities is recommended.
Keywords: CRDL, technology, dementia, engagement
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Assistive Technologies for Older Persons with Intellectual Disabilities. A Preliminary Systematic Review for Future Research Implementation

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Background: The number of older persons, including those with disabilities, has increased substantially in most countries and it will accelerate in the next decades. Among this population, experts have established a conceptual and factual distinction between two different phenomena: *disability with aging* (elderly incurring into some kind of impairments) and *aging with disability* (elderly who incurred into impairments during the developmental age). In both cases, assistive technologies (AT) can play an important role in supporting and stimulating elderly with disabilities in order to improve their quality of life and to support them in cognitive and social skills maintenance. In particular, the present paper aims at mapping the state of the art in ATs developed in the last 5 years for older persons with intellectual disabilities (ID).
Method: Adopting PRISMA checklist, a *systematic review* was conducted in IEEE Digital Library, ACM Digital Library and Scopus databases using the following keywords: a. assistive technology OR assistive devices OR domotics; b. accessib*; c. disabil* older people OR disab* elderly; d. intellectual disability OR mental retardation; period: 2014 to 2019. Inclusion criteria were scientific papers, proceedings and book chapters addressing the topic of interest. Studies that did not include older adults/elderly with ID and researches that did not focus on the use of ATs and related devices (indoor/outdoor, embodied, etc.) for these target-users were excluded.
Key results: After an initial selection of 520 articles, 61 were subjected to in-depth analysis leading to the final selection of 45 papers. The selected contributions reflect a heterogeneous variety of ATs (prototypes, on-purpose/low cost/commercial devices, etc.) that can support the older persons with cognitive impairments: advanced sensors/networks (n.10); cognitive assistants (n.3); robots (n.3); wireless communication systems (n.14); wearable technologies (n.6). Moreover, some papers (n.5) collect or combine different kind of devices while a few (n.4) face the economic, ethical and legal issues connected to the use of ATs with older/disabled persons. In the majority of the studies, these ATs were developed for older persons who acquired some kind of cognitive impairments (e.g. dementia) in older age (n.18) or, according to their designers, could be used both for age-related cognitive disorders and for older persons with life-long ID (n.20). Only a few studies (n.7) focused on the use of ATs for persons aging with ID.
Conclusion: The paper reports on the increasing number of ATs designed to assist elderly with cognitive disabilities to meet their needs. Simultaneously, it highlights that only few researches focus on AT devices for persons aging with ID. This confirms the lack of theoretical/concrete integration between aging and disability studies. These aspects, together with premature aging (generally associated with ID), result in limited understanding of how the experience of living with a long-term disability influences the experience of aging. Consequently, more attention to, and the development of ATs specifically designed for the aging population with ID is needed. New challenges for future researches will be addressed and further possible exploitation/application for supporting "successful aging with disabilities" will be drawn.
Keywords: Intellectual disabilities, Older person, Aging with disability, Assistive Technologies.
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Virtual Garden for People with Dementia

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Background: SENSE-GARDENs will strengthen the awareness of older people with dementia by providing stimuli to the different senses, such as sight, touch, hearing, balance and smell. In this study, several prototypes of the AAL-project were tested. For the Reality-Wall – a large screen showing film and photos, with sounds and music, and matching vibrations - the content must be tuned to a person's cultural background. In this study the desires and needs of Dutch older people with dementia in relation to the Reality-Wall were researched, with the goal to have content for the Reality-Wall when implemented in the Netherlands. The Liferoad/Cycling-Home consists of a stationary bicycle in front of a screen on which the environment of the cycle route is presented. In this study, various technological set-ups were tested with the goal to increase the sense of immersion to improve the well-being of people with dementia.
Method: In co-creation with nine people with dementia (phase CDR-2 and CDR-3) and their family, moodboards were created illustrating what kind

of films, music, tv-shows, art, etcetera would fit peoples' interests and bring up good memories. Based upon these moodboards, a 24-minute film with 21 fragments in four categories (TV; photo with sound; TV with music; photo) was created to test, using participatory observations. Five people with dementia (phase CDR-2 and CDR-3) were shown the film twice (with and without a family member), while researchers measured the number of verbal/non-verbal, social/non-social behavior for each fragment, using the Verbal and Nonverbal Interaction Scale. For the Life-road/Cycling-Home twenty care-home residents with dementia were randomly attributed to two out of four test settings (Google Streetview (personal choice of environment); 360-degrees video of the care-home environment; Bikelabyrinth (commercially available interactive routes); ClubVirtual (commercially available virtual cycling routes). Participants were seated in front of a stationary bicycle and a television screen, and were cycling for three minutes per test setting. Two researchers made observations, using the Discomfort Scale – Dementia of Alzheimer Type (DS-DAT), using a 5-point frequency scale.

Key results: During the 24-minute film for the Reality-Wall, participants mainly showed non-verbal social behavior. TV fragments with music resulted in the strongest reactions ($F = 6.66$, $df = 3$, $p < 0.01$). In comparison to observations without a family member, participants showed more verbal social behavior ($t = -2.54$, $df = 20$, $p < 0.05$), more non-verbal social behavior ($t = -2.22$, $df = 20$, $p < 0.05$), and less non-verbal non-social behavior ($t = 4.26$, $df = 20$, $p < 0.00$), when a family member was present during the 24-minute film. For the Life-road/Cycling-Home test, the 360 degrees video resulted in the lowest average discomfort score (DS-DAT score: 7.2). The Google Streetview setting resulted in the highest discomfort when tested first (DS-DAT: 11.2), but the lowest discomfort when tested second (DS-DAT: 5.9; $t = 2.10$; $df = 8$; $p < 0.10$).

Conclusion: All fragments resulted in more social than non-social behavior, some fragments stronger than others. The presence of family members increased verbal social behavior. The film seems suitable for residents with dementia of Dutch care-homes. 360-Degrees videos are useful for the Life-road/Cycling-Home prototype. Participants experience no extra value in interactive routes.

Keywords: Dementia, Virtual Environment, Co-creation, Stimuli.

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Dementia Dogs and their Impact on Community-dwelling Persons with Mild to Moderate Dementia and their Family Caregivers

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Background: Individuals with mild to moderate dementia, and their caregivers, may benefit from the support of a dementia dog. It falls into the category of cognitive aids (assistive technology for disabilities). It's a dog trained to provide cues (and sometimes reminders) and companionship, improve activity-levels and wayfinding, and enhance well-being and connection. There are very few schools that have a formal training program to train dementia dogs; we have found one dog schools in USA, one in Scotland and one in Australia. Since there is no scientific evidence addressing the efficacy of dementia dogs, our study proposes the following research objectives: 1-to examine the impacts of canine assistance on both the person with dementia and his/her caregiver (e.g., on engagement, socialization, well-being, activity levels, wandering, sense of meaning and purpose, quality of life, stress and health); 2-to conduct a cost-effectiveness analysis associated with having a canine assistance in the home of the person with dementia (e.g., costs related to dog acquisition and community training, post-placement, costs savings; benefits measured in terms of quality of life for caregivers and those with dementia); and 3-to examine the acceptance of canine assistance in public places in the prior 3 months from the caregivers' point of view (e.g. approachability situations and socialisation experiences).

Method: A comparative analysis of 3 'cases' is underway. Each case will be comprised of 20–40 dyads of a caregiver, person with mild to moderate dementia, and either (1) a companion dog, (2) a certified support dog, or (3) no dog. Data collection will include phone/Skype interviews with caregivers, a cost-

effectiveness analysis and observation at dog training schools. Phone questionnaires used are the Concern for the Care recipient's Well-Being (CCWB) and the Impact on the Caregiver's Social Life (ICSL) (two subscales of the Caregiver's Burden Scale). Online questionnaires used are the Adult social care outcomes toolkit (ASCOT), the Social care-related quality of life (SCRQoL), the ICEpop (Investigating Choice Experiments for the Preferences of Older People) and the CAPability measure for Older people (ICECAP-O). A qualitative thematic analysis of interviews and comparisons of the quantitative data across the 3 cases will be conducted.

Key results: Preliminary results on canine assistance has a positive impact on the lives of persons with dementia and their caregivers (supporting engagement, quality of life, well-being of the dyads, and enabling the person with dementia to remain at home safely and the caregiver remain or return at work).

Conclusion: With more results about canine assistance, it may be possible to advocate for the establishment of new training programs for certificated dementia dogs across Canada. Furthermore, positive results from the cost-effectiveness analysis and acceptance of the dementia dogs in public places will inform policymakers about the feasibility of funding certified dogs and to establish the associated public policies.

Keywords: Cognitive aid, Emotional support dog, Alzheimer, Home support, Caregiver facilitator.

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Family Caregivers' Experience of Care and Use of Assistive Technologies

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Background: Nearly half of the Canadians will be family caregivers (individual who provides unpaid assistance to someone living with a chronic condition) at some point in their lives. Family caregivers provide 75% of the care needed for individuals with disabilities to remain in their communities. Caregiving has psychological, physical and financial consequences. Considering issues associated with caregiving, finding ways to reduce caregiver burden is critical. Research has shown that the use of assistive technologies could decrease caregiver burden. However, it is essential to know how caregivers experience care and use of assistive technologies. This knowledge would guide the development of assistive technologies that are appropriate to their situation. This study aimed to explore the experience of caregiving for older adults, whether assistive technologies are currently integrated in the care and their perceived impacts.

Method: This study draws on data from a larger multisite, mixed-methods project on Canadian family caregivers. Sites of recruitment and data collection are Vancouver (English-speaking participants) and Québec City (French-speaking participants). To be recruited, family caregivers had to speak French or English, be at least 19 years old and provide care to an older adult, or be an older adult providing care. Participants were selected during recruitment to obtain a maximum theoretical variation in terms of impairments of the person for who care was provided (i.e., physical and/or cognitive), relationship with the care recipient (e.g. spouse, child, etc.), the amount of care provision and region in Canada. Between November 2015 and October 2017, 59 family caregivers were recruited and participated in an individual semi-structured interview on their current caregiving situation and their use of assistive technologies. Participants were informed that, when asked about assistive technologies, they could talk about services (e.g. home care services), policies (e.g. care funding) and assistive devices. A thematic content analysis was conducted.

Key results: Three main themes were identified from the interviews that describe family caregivers' experiences of care. 'Responsibilities of Caregiving' described that caregivers assisted in all areas of their care recipient's life, but some factors modulated the specific

activities for which help was provided and the type of help. An example of a modulating factor was their care recipients desire for autonomy. 'Caregivers' Challenges and Rewards' portrayed the daily challenges experienced by caregivers, such as physical strain, mental difficulties, the need for external assistance, etc. but also identified positive caregiving activities. 'Strategies to Address Responsibilities and Challenges' illustrated that caregivers use a variety of strategies to face their daily challenges, including the use of assistive technologies, but some needs are not fully addressed.

Conclusion: We developed a better understanding of the complexity of care provision, including daily challenges and needs that are not fully addressed, which may be affected via appropriate access to and use of effective assistive technologies. This study is a first step toward user-centred design research to develop innovative assistive technology solutions and areas where advocacy is needed to improve access to existing devices and services.

Keywords: assistive technology, caregiver, older adults, needs, mixed-method, interview.

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Evaluation of an Assistive Technologies Bundle by Informal Carers of Older Adults. Results from a Pilot Trial in Austria and Italy

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Background: There are many assistive and smart home technologies, but a residential gateway that connects them and thus creates an interoperable and adaptable technology bundle for older adults is still missing. Within the project gAALaxy, funded by the European AAL programme, such a bundle was developed and evaluated. The main research questions regarding informal carers focused on the usability of the bundle, perceived effects on well-being and quality of life variables, as well as different care aspects.

Method: The technologies were evaluated in an exploratory field study. Community-dwelling older adults and their informal carers from Austria and Italy tested a bundle, consisting of an emergency watch, a fall detector and a smart home system, for six up to 18 months. The trial period was conducted in two phases, with the middleware of the bundle being improved before the second phase. Here, we present parts of the results, i.e. the analyses of a questionnaire filled in by 38 informal carers. It measured attitudes towards technology, the perceived impact of the bundle on the older adults and themselves, and the perceived usability and ease of use of the bundle. In pilot phase two we also asked participants about their willingness to pay for the technologies.

Key results: Statistical analyses showed that there were virtually no significant differences between phase 1 and 2 regarding the perceptions of informal carers. Surveying the impact of the bundle on different variables across both phases, we found mostly positive values though. The perceived effects on care quality, ease of use, peace of mind, comfort, safety, autonomy, and social interaction were all positive, with a total mean of 1.14 (SD: 0.64, seven-point scale from -3 to $+3$). The mean perceived usability of the bundle was 1.63 (SD: 0.89, seven-point scale from -3 to $+3$). The ability of the bundle to recognise emergencies quickly was rated especially positively (mean: 1.45, SD: 0.81, five-point scale from -2 to $+2$). Only the perceived effort of using the bundle as an informal carer was rated slightly negatively (mean: -0.62, SD: 0.92, five-point scale from -2 to $+2$). 10 informal carers reported some future willingness to pay a monthly fee for the whole bundle including services, with a wide range of acceptable monthly fees being stated (mean: 57.19e, SD: 52.57e).

Conclusion: The lack of differences between phase 1 and 2 in terms of general technology attitude and evaluation of the bundle is not surprising as the bundle changed little over time from the end-users' point of view (the improvements were of a technical nature and had no noteworthy effects). Even if there were no statistically significant increases of the perceived quality and effects of the technology bundle over time, we can still state that the overall perception by the informal carers was almost always positive in both phases. The exploratory nature of the research design did not allow sophisticated statistical analysis methods. We therefore consider the results as preparatory for bigger scale projects (e.g. i-evAALution, also funded by the AAL programme).

Keywords: Assistive Technologies, AAL, Older Adults, Informal Carers

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Evaluation of Daytime Activities at Home for Elderly Hemiplegic Patients and Development of Bed with Standing up Function to Prevent Disuse Syndrome

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Background: The rehabilitation service of elderly hemiplegics patients at home to prevent disuse syndrome play an important role in Japan. However, the actual activity level of patients and the effectiveness of the rehabilitation are not clarified objectively. The purpose of this study is to evaluate their activities with Activity Monitoring Evaluation System (AMES) and to develop the bed with standing up function to prevent disuse syndrome. The bed can take the forms of very adjustable profile electrically, so that the patient is able to achieve a standing position through a sitting position from horizontal lying position.

Method: We examined the activities of 30 hemiplegic patients (71 $\pm$ 3.5 years, 22 males, 8 females) with AMES while 8 hours (9 am to 5 pm) for 2 days. AMES could derive the activities such as walking, propelling wheelchair, standing, sitting, and lying position on bed. We evaluated total duration time, percentage and maximum continuous time of each activity. In order to verify the efficiency of the bed in almost bedridden another 2 hemiplegic patients (83 years male, 87 years female), to take standing position for 30 minutes was performed twice a day for 30 days.

Key results: 1. Mean total duration time, standard deviation were that walking: 55 $\pm$ 37min, propelling wheelchair: 33 $\pm$ 34 min, standing: 27 $\pm$ 21 min, sitting: 270 $\pm$ 100 min, lying position: 116 $\pm$ 119 min. 2. The mean percentage of each activity against to 8 hours were that walking: 12%, propelling wheelchair: 7%, standing: 6%, sitting: 56%, lying position: 24%. 3. Mean maximum continuous duration time and maximum time were that walking: 6 min (27 min), propelling wheelchair: 49 seconds (1.5 min), standing: 2 min (9 min), sitting: 43 min (2 h 14 min), lying position: 43 min (2 h 40 min). 4. The standing up with the bed increased serum proteins and hemoglobin that indicated the improvement of anemia and nutritional state, and improved edema in the lower extremities and ADL level. However, these results showed only slight improvement, with no statistically significant differences.

Conclusion: The percentage of walking and standing is only 18%, whereas that of sitting and lying position is about 80%. Nine subjects show that the percentage of walking is lower than 10%. The percentage of sitting time 56% shows that the subjects have been sitting half in a daytime. The mean percentage 24% of lying position indicates that some subjects are staying in bed through the daytime, and 9 subjects have been lying for over 3 hours. The results reveal that the amount of daily activities of the hemiplegic patients in a daytime is unexpectedly low, and predict those patients may be caused a disuse syndrome. The standing up function of the bed is clinically useful, for selected patients who could show good prognosis in ADL stage. However, the primary purpose of the bed is to facilitate a change from a supine position to a sitting position and to lead from a standing position to walk. So, further study to verify the effect of the multi adjustable forms bed with AMES for improving the activity level of hemiplegic patients is required.

Keywords: Elderly hemiplegia, Daytime activities, Rehabilitation service, Standing up bed, Disuse syndrome.

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Detecting Social Interaction in a Smart Environment

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Background: Over the last few decades, numerous articles and studies have shown the relationship between loneliness and its effects on people's health, especially in the case of senior citizens. Detecting loneliness requires a meticulous and continuous observation of the subject by clinicians. However, considering the growth of the population over sixty, the huge demand for health-care facilities, and the necessity to contain the costs of hospitalization, the technology is now called to support the activities of specialists. An open challenge is to measure the level of social interaction among people, and to infer a personal "loneli-

ness" index. We propose a system to identify the interactions among people who are sharing the dining table in a smart environment.
Method: This study refers to an experimental investigation conducted in "Il paese ritrovato", an innovative health-care facility located in Monza, Italy, that assists people affected by Alzheimer Disease. The system detects the patients who are sitting around a table and their position; this information is computed integrating an environmental Bluetooth indoor localization system and an RFID module installed on the table. Moreover, the system detects the social interactions: a quad-microphone array expansion board for Raspberry Pi called ReSpeaker Mic 4-Array detects the direction from which someone is speaking. A dedicated software filters the data locally, and computes a "social index" among the people who are sitting around at the table. The communication between the main module and the devices has been implemented using MQTT, a publish/subscribe mechanism.
Key results: The experiment has been carried out in an indoor environment, by placing the system on a four-sided square table with four people, one for each seat. During the testing phase, the system has been tested under three different environmental conditions: in absence of noise and voices aside from the speaker, in presence of noise and with other people speaking in the surroundings of the system. Overall, the system shows promising results (precision: 84%, recall: 93%, accuracy:79%) only, in presence of loud noise, the system is still not able to identify with precision the people who participate in the interaction. We strongly believe that the computed index constitutes a valuable source of knowledge for further data analysis modules (such as the one installed in "Il paese ritrovato") to monitor patients.
Conclusion: A novel system to identify the interactions among people who are sharing the dining table in a smart environment has been presented. Thanks to a localization module based on both Bluetooth and RFID technologies, and a microphone, this system is capable to measure the level of social interaction among people. As future work, we plan to investigate the possibility to extend the system to detect social interactions in wide open spaces through the integration of a device capable of recognizing the speakers' voiceprints.
Keywords: Wellbeing assessment, Assistive Technologies, Social interaction, Smart Environments, IoT.
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Continuous Ambient In-home Walking Speed Monitoring in Frail Older Adults: Results of a Feasibility Study

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Background: Walking speed has been shown to be predictive of important clinical outcomes in older adults and has been labelled 'the sixth vital sign'. Furthermore, it has particular value as one of the most significant indicators of frailty. Despite the clinical importance of walking speed measurement (and its inclusion in guidelines regarding frailty, multi-morbidity etc.), measurement of walking speed is rarely carried out. It is not feasible to carry out clinic-based walking speed measurements with sufficient frequency to capture the rate of change of health in older people and as a result important heath deterioration is missed and health services end up reacting to crisis situations (e.g. falls). Our aim was to test whether it is feasible to measure walking speed frequently and unobtrusively in the home, using ambient technology that is easy to install and reliable (therefore usable in a health and social care setting), low cost, and acceptable to older people.
Method: A longitudinal feasibility study was conducted involving 20 older adults (aged 65 or above) living alone, identified as either frail or pre-frail by the Rockwood Clinical Frailty Scale (score between four and six). Self-selection sampling was employed within the populations of two supported-living services in Sheffield, UK. Sensors were installed in the participants' homes for a period of three months to continuously measure their walking speed. The researcher visited each participant at four time points (baseline and monthly intervals) to conduct manual walking speed measurements, administer the Rockwood Clinical Frailty Scale and a brief health interview, and collect the data from the memory cards of each device. Qualitative interviews were also conducted at the end of the study to assess participants' attitudes to the sensors and the concept of continuous in-home walking speed measurement.
Key results: Eighteen participants completed the study, with two withdrawing, one due to personal preference at month one and a second due to a change in living circumstances at month three. The number of walking speed measurements recorded by the sen-

sors varied significantly between participants (mean 1159.39, range 4–3636); the number was determined by the placement of the device within each home and technical disruptions to the sensor operation, as well as the individual's lifestyle and degree of mobility. A near-normal distribution of speeds was evident for several participants for whom placement was good and disruption was minimal. Qualitative interviews with the participants indicated both acceptability of the device within the home environment and of the concept of measuring walking speed as an indicator of physical health.

Conclusion: This study has demonstrated the feasibility of continuous ambient in-home walking speed monitoring in older adults. Further development of the walking speed sensor is required to increase placement flexibility, improve accuracy and allow for wireless integration with online services. This will lead to a device that can be used both to support self-management of frailty and monitoring of frailty by healthcare providers.

Keywords: Frailty, Walking speed, Ambient sensor technology.

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Effectiveness of Sensor Monitoring in a Rehabilitation Program for Older Patients After Hip Fracture: A Three-arm Stepped Wedge Randomized Trial

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Background: The performance of activities of daily living (ADL) at home is important for the recovery of older persons after hip fracture. Fear of falling hinders older persons to perform ADLs. Sensor monitoring can be used as a coaching tool to reduce fear of falling and increase daily functioning. However, as far as we know, sensor monitoring-based programs have not yet been used in rehabilitation for older patients after hip fracture. In this randomized trial, we tested the effects of an intervention involving sensor monitoring informed occupational therapy on top of a cognitive behavioral treatment (CBT) based coaching program on patient- reported daily functioning in older patients after hip fracture.

Method used: The study was a three-armed randomized stepped wedge trial in six skilled nursing facilities, with assessments at baseline (during admission) and after one, four and six months (at home). Eligible patients were hip fracture patients 65 years and older. Patients received care as usual, CBT-based occupational therapy or CBT-based occupational therapy with sensor monitoring. The sensor monitoring system comprises 1) a wearable physical activity monitor (PAM-sensor) that is worn on the hip; 2) a network of ambient sensors comprises (Benext)passive infrared motion sensors placed in the main spaces in the patients' house and 3) a gateway, that is a raspberry Pi with a Z-wave shield for communication with the ambient sensors, a Bluetooth adaptor for communication with the PAM and a 4G dongle to make connection with the remote server. Via a web-based application users can login to the server and see the visualizations. Interventions comprised a weekly session during institutionalization, followed by four home visits and four telephone consultations over three months. The primary outcome was patient reported daily functioning at six months, measured with the Canadian Occupational Performance Measure.

Key results: A total of 240 patients (mean[SD] age, 83.8[6.9] years were enrolled. At baseline, the mean Canadian Occupational Performance Measure scores (range 1–10) were 2.92 (SE 0.20) and 3.09 (SE 0.21) for the care as usual and CBT-based occupational therapy with sensor monitoring groups, respectively. At six months, these values were 6.42 (SE 0.47) and 7.59 (SE 0.50). The mean patient-reported daily functioning in the CBT-based occupational therapy with sensor monitoring group was larger than that in the care as usual group (difference 1.17 [95% CI (0.47–1.87) $P = 0.001$]. We found no significant differences in daily functioning between CBT-based occupational therapy and care as usual.

Conclusion: Among older patients recovering from hip fracture, a rehabilitation program of sensor monitoring-informed occupational therapy was more effec-

tive in improving patient-reported daily functioning at six months than to care as usual. The findings have important implications for those active in the support of older patients after hip fracture. A successful implementation of this intervention, requires the use of goal setting and CBT-strategies to motivate patients to increase daily activities with the goal to recover. The objective information of the sensors provides professionals with more detailed information about daily activity patterns, so they can more effectively discuss goals and coach patients to recover.

Key words: Geriatric rehabilitation, sensor monitoring, cognitive behavioral treatment

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HABITAT: A New Generation of Ambient Assisted Living

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Background: Over the last years, due to the increasing median age of the world population, solutions devoted to home living assistance are becoming a matter of urgency, enhancing interests throughout the scientific community. In particular, HABITAT (Home Assistance Based on the Internet of Things for the AuTonomy of Everybody) is a project addressed to families, caregivers, and to everyone who needs support in daily activities in order to guarantee increasing safety and to encourage the maintenance of a healthy lifestyle. The presented solution consists in a platform based on the typical technologies of Internet of Things (IoT), namely RFID (Radio Frequency IDentification), Wearable Electronics, Wireless Sensor Networks (WSN) and Artificial Intelligence, which allows to realize reconfigurable assistive environments.
Method: After an in-depth analysis of needs, carried out through interviews and focus groups involving the real users living in adult daycare centers, more than 450 requests were collected; based on these wishes, everyday life objects have been enhanced with brand new functionalities, with the aim of making them become "smart". As an example, a common wall lamp integrates an innovative indoor localization system, an armchair allows to detect the sitting posture and finally a belt incorporates a mobile health system able to perform an indoor and outdoor gait analysis. Concerning the indoor localization, a RFID reader (with maximum read range of 5.50 m and angular aperture of $\pm$ 45°) able to localize and track both people and objects equipped with RFID tags, has been developed. Thanks to the limited thickness of the reader, this technology is able to be inserted in any piece of furniture inside the house, i.e. hung on the wall inside a frame. Furthermore, a small RFID tag completes the overall system and can be worn by the users in a discrete way, like a brooch, a pendant, or with the antenna directly integrated in the textile materials. After preliminary laboratory investigations, 40-minute tests have been performed on 19 subjects, including caregivers, self-sufficient and non-self-sufficient seniors, from 55 to 83 years old, volunteers from a daycare facility on the outskirts of Bologna (Italy).
Key results: During the abovementioned tests, both the technology of the smart objects and their acceptability were validated and deeply investigated: with regards to the indoor localization, mean errors of about 18 cm were detected within a room of 32 m^2. During the project, deep focus has been pointed towards the acceptability of the technology, together with the object design usability and their interaction with the final users.
Conclusion: In this work, a new version of AAL (Ambient Assisted Living) system addressed to elderly people living in their own houses or in daycare centers has been described; its future aims forecast improvements on the technology functionalities and on the user-friendly designs of the smart objects.

Keywords: Ambient Assisted Living, Elderly, Internet of Things, Assistive Technology.

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LivingHub: An interdisciplinary approach to designing an innovative AT laboratory for ageing population by using simulation-based education

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Background: Simulation-based education methodology, born in the military field, has since earned

widespread recognition in many fields as a powerful tool to strengthen knowledge, improve team communication and teach the skills of decision-making processes. Many Universities in the world have set up their own simulation laboratories, teaching and research centers, predominantly in engineering and medical areas. In particular, simulation based medical training enables students, physicians, nurses and other health professionals to integrate cognitive learning with practical experience, without posing risks to the patients. Today the use of simulation has surpassed military and medical applications and has allowed the development of transversal didactic teaching methods that could cover a wide range of new training needs.

Devised from the confluence of transdisciplinary skills (medicine, engineering, computer science, architecture, design) according to the AAL (Ambient Assisted Living) approach, this work presents the LivingHub project: a smart prototype apartment (about 70 square meters) to simulate domestic environments for ageing population integrated with systems of monitoring, control and assistance.

The LivingHub objective is to promote the spread of a new home healthcare culture that passes through simulation-based education, designing suitable spaces and devices and developing specific professional skills. Furthermore, the LivingHub wants to provide a reference model for new research and training opportunities in the field of interdisciplinary and interprofessional skills, across different scientific areas.

Method: Currently under construction, the LivingHub is being built as a movie set (folding triangular truss with audio-video-light system) consisting of four main rooms (bedroom, living room, bathroom, kitchen) and a control room.

The LivingHub is a home-laboratory (according to the model of the MIT Living Labs: http://livinglab.mit.edu/) where different actors (coming from universities, companies, research centers, public institutions, citizens) have the chance to exchange ideas, following a multidisciplinary and user-centered approach able to promote innovation.

Starting from the detection of users' needs in carrying out daily activities, simulation training scenarios are built with technological aids by formal and informal caregivers, with particular attention to the concepts of accessibility and usability.

Key results: The LivingHub aims to create a hub that combines various functions, such as an educational laboratory for students and professionals, a showroom of technologies and services in AAL field, a research and development laboratory for assistive technologies and services.

Conclusion: The LivingHub not only aims to educate, through simulation, future highly qualified care professionals, but is also aimed at generating user-centered ecosystems, able to accelerate the large-scale adoption of assistive technologies and co-created services with the users themselves. The LivingHub encourages the integration of domotic technologies into the domestic environment with monitoring and remote assistance systems (telemedicine, tele-monitoring, robots for telepresence, remote data processing. . .).

Keywords: Simulation-based education, Interdisciplinary approach, AAL laboratory.

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Technology and Disability 31 (2019) S125–S132
DOI 10.3233/TAD-190006
IOS Press

Part 3: Mobility

Travelers with Disabilities: Challenges and Assistive Technologies

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Background: This paper describes the preliminary results an ongoing project in the area of accessible tourism, which is currently being run by different universities, industrial partners and selected hotels. The first goal of the project is to systematically identify the barriers that travelers with disabilities encounter today when going on holidays. Another goal of this project is to build so-called Hotel-Living-Labs (HLLs). These are hotel rooms that are generally accessible and which are equipped with assistive technologies as well as assistive services. The HLLs serve as a test bed where assistive technologies and services can be evaluated in a realistic holiday environment. The last goal is to iteratively build an overall service for travelers with disabilities who wish to enjoy accessible holidays in a customer-centered way, together with the different customer groups with disabilities and their accompanying persons.
Method: Firstly, a literature review of potential barriers for travelers with disabilities and elderly travelers was performed, and assistive technologies/services were proposed for overcoming these barriers. These identified potential barriers are currently being verified in a series of ongoing interviews, which are being conducted with 25 individuals, separated into four categories: persons with vision impairments, persons with hearing impairments, wheelchair users, and elderly persons. Each interview lasts 1 hour. The findings from the interviews will be compared with the findings of the literature review. The results will then be used to develop a number of fully accessible "hotel living lab" rooms, where the travelers' experiences will be evaluated via a questionnaire.
Key results: The initial literature review revealed that, apart from facilities or services not being accessible themselves, many of the identified potential barriers are related to information offered by missing, inaccessible, outdated, inaccurate or inadequate information offered to the guests by the providers of assistive technologies/services before and during the holiday stay.
Conclusion: Accessible Tourism is an important goal to achieve in order to allow travelers with disabilities and elderly travelers to enjoy their holidays to the same degree as anyone else. Because the preliminary results of this project have indicated that many of the existing barriers occur because important information is missing, inaccurate, or inaccessible at different steps of the holiday journey, the project will focus on applying digital assistive technologies that allow this information to be provided in an accessible manner.
Keywords: Accessible tourism, interviews, assistive technologies
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People Moving in a Smart City

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Background: In Italy, several projects for the deployment of ICT infrastructures to support the smart city concept are active. One of the main components is the control of the vehicles traffic. However, the needs of pedestrians should be considered, aiming to guide their navigation in the city and to offer support if they have problems. The system should be inclusive and personalized, including: (i) people without specific requirements (e.g. with context-based instructions and allowing requests in free format); (ii) fragile people as old people offering additional support (e.g. telling them where they are, if they are lost, and guiding them home); (iii) people with activity limitations, with supports based on their specific limitation (e.g. giving accessible information about the environment).

Method: An innovative structured procedure will be used, based on the identification of the functionalities necessary to support the activities listed in Chapter 4 of the WHO ICF classification, d450 Walking, d460 Moving around in different locations, d470 Using transportation, d475 Driving, their organization in services and the integration in social networks. This approach has been tested in a system developed in our laboratory, which addresses Chp. 6 Domestic life, in particular feeding and Chp. 7, Interpersonal interactions and relationship. It allows the choice of a recipe (with control of health problems), the automatic management of the pantry and of the shopping list, the step-by-step assistance in the preparation of dishes. When people do not have the necessary abilities, AT is used when suitable (e.g. for the interface adaptation) or special support is offered (for example simplification of the procedures for people with cognitive difficulties). Useful comments have been collected during the evaluation though an (adapted) Pluralistic Usability Walkthrough (PUW). Then, the knowledge acquired in the implementation of a second system dealing with a psychological problem of people, who live alone, i.e. solitude, will integrated introducing elements of "intelligent" support for adaptation to people and situations. This system identifies the situation of people from their behavior and trough a learning component supports them with suggestions (not decisions). from the system itself and/or from the social network – An evaluation of the system is under preparation in a sheltered condominium in Florence.
Key results: The main result is the conceptual verification of the structured design procedure of support systems, which starts from ICF and is based on the support by technology, by connected people, and by artificial intelligent components to learn from their real use and to adapt them to the individual person. This implies the functionalities of a navigation system, the cooperation of people (in the social environment or in vicinity of the moving person), and intelligence in the system, to collect information about the situation and reactions of moving people and their social environment, reasoning on these data to devise personalized suggestions.
Conclusion: The above-cited results appear good starting points to be generalized to a more complex environment, together with the identification of the impact on assistive technology suitable for its use in a mobile and public environment.
Keywords: Services, ICF, Mobility.
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Challenges in Indoor Navigation and Accessibility
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Background: Independent mobility is a primary concern for inclusion of visually impaired (VI) people. Indoor mobility is challenging because of information unavailability, structural complexity, poor representation and lack of orientation and mobility training. Adoption of new technology including security concerns creates more complications in independent accessibility. Some of the critical indoor facilities that demand accessibility includes hospitals, and transport terminal. This work is an effort to create a more reliable technological solution for accessible indoor navigation for VI. Current research like NavCog and Soundscape for supporting indoor and outdoor navigation focuses on improving localization accuracy and audio-based information delivery but have challenges like reliability and cognitive load. Empirically we found, indoor navigation requires contextual localization accuracy and hierarchical information delivery for better non-visual cognitive mapping while most of blind navigation methods do not include this. Our key motivation here is to investigate how an indoor navigation representation scheme works for VI and how technology could play a role in inclusive navigation interface design.
Method: Our approach is based on creation of information representation scheme influenced from sighted navigational cues (like decision point, progressive disclosure and information reinforcement) from indoor. We have done a preliminary survey to understand indoor navigation cues for sighted. The indoor representation scheme for navigation using regular signage (already tested in a hospital) helps us to understand and annotate building maps with navigation and safety related information (entry/exit, doors) and services (lifts, stairs, ramp, drinking water and washrooms) required by all the users. We include additional annotations like floor surface change (e.g. small steps or ramps) and protrusion in the corridors (e.g. fire extinguishers) to enhance accessibility and to generate a rich annotated map with additional meta-data. One important step we are examining to get scalability to other public buildings is the possibility of extracting required annotations from videos. We use beacon and user input-based course localization and audio-based feedback using smart-phone. We are now in the process of conducting

a study with VI users to test our system. It is expected that such representation scheme and associated interventions can contribute to open standards for indoor navigation and accessibility.

Key results: We have some key findings from our limited trials in a public hospital in New Delhi, India. The emphasis has been on an inclusive solution due to a diverse demography of users and affordability that involves effective utilization of existing infrastructure to make the solution cost-effective and scaleable. Our study has shown that providing right information at right place can be very effective in indoor spaces. Trials have shown that prior information about upcoming landmarks within indoor spaces is helpful. Progressive disclosure of information and timely reinforcement can help in reducing cognitive load. Ongoing research states that non-visual cognitive mapping of environment can enhance retention using such cues.

Conclusion: This paper deals with problem of indoor navigation for VI. We found right information at right time is a key to reliable indoor navigation. Our limited trials suggest that an information representation scheme and contextual localization can handle the diversity in user group and should be included in open standards for indoor navigation and accessibility.

Keywords: Accessibility, Indoor navigation, Mobility, Visually impaired, Cognitive map, Localization.

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An Affordable Concept to Produce Mobility Devices in Low Resource Settings

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Background: In many low resource settings even the most basic assistive devices are not available, and if available, they are often not affordable for the people who need them. Therefore the World Health Organisation (WHO) has identified the development of affordable high quality assistive devices as a global research priority. In this presentation we present the results of a project in which we looked at the possibility of producing frequently used assistive devices in more efficient ways, and make them more suitable for the specific context of low resource settings. We focused on mobility aids as listed in the WHO Priority Assistive Products List. With an international team of experts in manufacturing technologies, product design, assistive technology provision and rehabilitation professionals in India and the UK we developed an innovative concept for locally producing mobility devices.

Method: The project consisted of three phases. In the first phase we studied the most urgent needs in two areas in India, one in the city of Delhi and one in a rural area near Bangalore, using a survey method. In a second phase we made a technical analysis of the WHO Priority Assistive Products List from the perspective of more efficient production methods, and organized a multidisciplinary and international workshop to discuss the link between needs on the one hand and the possibilities of more efficient production methods on the other. This led to three promising possibilities: Adaptation and modification of existing AT solutions, End-user involved modular assistive devices and Assistive Technology App. In the third phase one of these was concretely developed into an innovative production concept by a team of product designers in the UK and India.

Key results: The result is a concept for producing three types of mobility devices (walking stick, crutches and walker frame). During the presentation this concept will be demonstrated and the approach followed to reach this result discussed. The concept is easy to produce at a low cost, devices can be generated locally 'on the spot' and individualized for the user, parts can be re-used and repair is very easy using basic hand tools. The personalisation has been incorporated in the assembly process by cutting the tubular components to a specific length for the particular end user. By removing the assembly process from the centralised manufacturer of the modular components and introducing it to local distribution centres the assembly costs are converted into jobs for the local community. A field trial in rural India with the new concept is being planned.

Conclusion: This project shows that it is possible to develop innovative concepts and methods that enable the production and assemblage of affordable and high quality assistive products. Multidisciplinary and international collaboration proved to be essential to achieve this. The resulting concept for mobility devices has the potential to greatly contribute to better availability in low resource settings.

Keywords: mobility, affordable, crutch, walker, produced locally.
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User Acceptance of Augmented Reality Glasses for Hand Exoskeleton Control

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Background: Every year about 260,000 people in Germany suffer a stroke, of which one third retain severe motor deficits. Particularly, loss of hand function leads to a considerable loss of autonomy and quality of life. We expect an actuated hand exoskeleton to provide them with daily life assistance and restore their hand function. However, hand exoskeleton control poses a considerable challenge for human-machine interaction. We follow up on Markovic et al. (2014) who have achieved promising results in hand prosthesis control using AR glasses.
Method: In a preliminary study, we investigated which AR glasses are suitable and acceptable by the users. In general, there are two types of AR glasses: (1) Large glasses with a real AR experience (e.g. Microsoft HoloLens); (2) Small glasses that resemble a head-up display (e.g. Epson BT-300, Google Glass). In order to investigate which type has higher user acceptance for controlling a hand exoskeleton, we implemented a prototypical assistance system without hand exoskeleton for the HoloLens and the BT-300. We evaluated them with 6 healthy test persons (age: M = 25.50 SD = 7.71). They indicated on a Likert scale (1 = not at all, 5 = definitely) whether they would use the respective AR glasses to control an assistance system for the following application contexts: (C1) private, (C2) public, (C3) rehabilitation environment. We also asked them how long they would comfortably use them in general. Based on the results of the preliminary study, the main study was a questionnaire focusing exclusively on small AR glasses. We asked 15 patients (10 stroke patients, 5 tetraplegics, age: M = 54.33 SD = 13.45) about their experiences with AR glasses and their theoretical acceptance for controlling a hand exoskeleton. All 15 patients had motor or sensory limitations in at least one hand. 8 of them could not grasp any objects with at least one hand and would benefit from a hand exoskeleton. Again, we assessed the user acceptance on a Likert scale. We also collected additional qualitative data.
Key results: The preliminary study showed that the subjects would wear the BT-300 (M = 48.10 min SD = 42.27 min) significantly longer than the HoloLens (M = 20.50 min SD = 15.00 min). Furthermore, the BT-300 (C1: M = 4.00 SD = 1.09, C2: M = 3.33 SD = 1.63 and C3: M = 4.00 SD = 1.55) has a higher user acceptance than the HoloLens (C1: M = 3.33 SD = 1.03, C2: M = 2.00 SD = 0.89, C3: M = 3.17 SD = 2.04).
In the main study, the 15 patients showed a high user acceptance (C1: M = 4.28 SD = 1.44, C2: M = 2.93 SD = 1.75, C3: M = 5.00 SD = 0.00) for small AR glasses to control the hand exoskeleton. However, 5 patients indicated that they would not wear AR glasses for at least one application context.
Conclusion: This study shows that small AR glasses have a high user acceptance for assistive system control in private and clinical environments. This brings about novel interaction possibilities with assistive systems. However, the results also show that – to date – many assistive system users do not want to wear AR glasses in public. Therefore, it is necessary that assistive systems such as hand exoskeletons can be operated by other input and output devices, aside from glasses.
Keywords: hand exoskeleton, augmented reality, assistive technology, user acceptance.
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Accuracy evaluation of an add-on acquisition system of operation log with inertial measurement units for a mobility scooter

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Background: In recent years, a mobility scooter spreads in society as a mobility aid for elderly people and plays a considerable role in maintaining the quality of life. Despite its convenience, severe accidents have happened with increasing number of users. To reduce accidents, appropriate measures of driving in daily use will be a possible solution. Therefore we developed a simple and easy-to-install acquisition system of operation log for detection of dangerous driving in daily use. The feature of this system is capability to quantify and record operations of the mobility scooter by only a few inertial measurement units (IMUs). The coordinate transformation of gravitational acceleration measured by IMU attached on the steering tiller can estimate two operation variables, i.e., the angles of the steering handlebar and the accelerator lever. This study aims to evaluate the estimation accuracy of these two variables and to optimize the combination of IMUs on the scooter body and the tiller.
Method: [Estimation method] The acquisition system is composed of two IMUs mounted on the body and the accelerator lever of the mobility scooter and the data logger on the front basket. The relation between the two operation variables and the gravitational accelerations measured by the IMU on the lever can be described by the coordinate transformation with rotation matrices. Solving this equation enables to convert the measurement data into the two operation variables. The IMU on the scooter body is utilized to compensate for the body inclination.
[Accuracy evaluation] The estimation accuracy of the proposed system was examined by changing the numbers of IMUs and axes (i.e. acceleration and/or angular velocity) used for calculation. The true values of the angles were measured by wire displacement sensors. The test course included flat and sloped surfaces. The similarity between the estimated and the true values was evaluated using the root mean square error (RMSE) and the correlation coefficient (CC).
Key results: The number of IMUs used for calculation mainly influenced the estimation accuracy with the presence of terrain inclination. The inclination compensation by the IMU on the scooter body was effective in the sloped surface with the inclination of over 7 degree whereas the inclination-induced estimation error was ignorable with flat surfaces. The use of angular velocities measured by IMUs was another factor impacting on the estimation accuracy. In some cases, the angle of the accelerator lever was estimated with better accuracy when the angular velocity was complementally used with acceleration. The estimation accuracy of the steering angle, on the other hand, was the best when estimated solely by acceleration measured with two IMUs. RMSE and CC with this estimation condition were 3.18 degree and 0.99, respectively.
Conclusion: The estimation accuracy of the operation variables of the mobility scooter were compared with different methods using acceleration and angular velocity. Consequently, we concluded that the combination use of 3-axis acceleration values measured by two IMUs is suitable for monitoring driving behavior in daily use.
Keywords: IMU, Power wheelchair, Skills evaluation, Lifelog.
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A Semantic Decision Support System to foster Return to Work of Novice Wheelchair Users

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Background: This work presents a Decision Support System (DSS) to foster return to work (RTW) of novice wheelchair users (NWU). The DSS is developed within an ongoing research project financed by the Italian National Institute for Insurance against Accidents at Work (INAIL). Following accidents at work, many NWUs decide not to come back to work, thus relying on the National Institute of Welfare for disability pensions; however, long-term unemployment could have a negative impact on NWU's mental and physical health. Within this context, the DSS aims at easing the process of RTW for NWUs by supporting therapists and vocational personnel with technological means in discriminating the still suitable jobs for each specific user.
Method: The DSS leverages semantic representations of the knowledge related to jobs and NWUs' functional capacity evaluation; for the first representation, O*NET (Occupational Information Network) vocabulary (the cross sections "Skills" and "Abilities",

which are common to all the professions mapped in O*NET) was converted into an ontology. For the second, four comprehensive Core Sets from the International Classification of Functioning, Disability and Health (ICF) – corresponding to the three primary conditions that force a person on a wheelchair: Spinal Cord Injury, Traumatic Brain Injury, Stroke, plus the Vocational Rehabilitation Core Set to address work reintegration – were modelled into an ontology to describe the functioning of NWUs. Each O*NET skill and ability describing a job was then translated into ICF, via a consensus forum involving two psychologists and two biomedical engineers. Using ICF qualifiers and O*NET importance scores for each "Skills" and "Abilities", the DSS leverages a set of rules to automatically match a NWU's functional capacity evaluation, performed with ICF, to a list of jobs he/she can still perform.

Key results: Up to date, the DSS can model any NWU's condition with ICF and match him/her with a list of possible jobs; the DSS includes 10 professions (4 clericals, 4 physicals, 2 middle-management), but its structure allows to easily add more jobs. The outcomes deriving from the reasoning processes of the DSS can highlight the skills and abilities in which the NWU may face some difficulties, thus helping the vocational personnel and therapists in deciding whether to suggest the NWU to return to a specific job, perhaps with the support of some facilitators.

Conclusion: The presented DSS, leveraging semantic web technologies and ICF, provides a common language for clinical and vocational personnel and allows the involvement of non-clinical personnel (employers), with the aim of fostering work reintegration of NWUs and enhancing their quality of life, thus decreasing the impact of work accident consequences in terms of private and social costs. In the following months, the presented DSS will be tested for technology acceptance and usability (using respectively TAM 3 and SUS scales) by INAIL personnel.

Keywords: wheelchair user, return to work, decision support system, semantic web, ontology.

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Wheelchair Users' Experiences with and Need of Activity Trackers

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Background: The use of different kinds of activity trackers, e.g. step counters, has become popular to monitor one's physical activity level. A typical goal for users is to evaluate whether public health recommendations stated by health authorities are met. Given a sedentary lifestyle, wheelchair users are particularly challenged when it comes to the performance of physical activity. However, activity trackers on the market are not applicable for wheelchair users. Obviously, steps are not a valid measure, but research suggest that other measures such as heart rate, wheel rotation and arm acceleration also have limitations. Yet, wheelchair users still use activity trackers, and their experiences are key to developing better technology.
The aim was to investigate: What are the wheelchair users' experiences of using current technological devices for activity tracking and, what are their requirements for future valid and meaningful activity tracking?

Method: A focus group interview was conducted, involving N = 7 wheelchair users; one woman and seven men in the age of 24–49. Participants were sampled thorough a wheelchair users basketball club. The focus group lasted for one hour. A semi-structured interview guide was developed to guide the interview. A content analysis was performed by the authors, first separately, then together to reach consensus and validate the findings.

Key results: Wheelchair users have some positive experiences with activity tracking using GPS-data e.g. some tracked whether the relationship between distance and time improved. However, they experienced that distance and time are the only parameters that are correctly measured, whereas calorie consumption, pulse, step and training intensity are not appropriately measured. The wheelchair users especially noted that some activity trackers provide reminders that assume that the user can walk, such as "it is time to get up and move around", which they considered meaningless. The wheelchair users experienced an un-met need to evaluate whether their overall physical activity was sufficient or whether they were too inactive, but none of the technologies that they had utilized, could provide this information, which includes exercise training as well as daily household tasks. In addition, the wheelchair users suggested that it would be motivating to compare current and previous achievements and compete with oneself and others. A surprising finding

was that wheelchair users experienced a need of understanding their own typical pulse alterations, to be able to prevent dizziness related to performance of physical activity. In addition, the wheelchair users were concerned that physical activity measures could be used against them and become a barrier for granting assistive technology.

Conclusion: Sound activity trackers are needed, specifically designed for wheelchair users. The benefits hereof are evident from a public health perspective, because we might identify wheelchair users with low physical activity levels. In an assistive technology perspective, appropriate use of information provided by activity trackers should be considered to avoid distrust among wheelchair users. In summary, activity tracking may be valuable for wheelchair users, health care and society at large. Future research should account for the limitations of this study i.e. few participants limited to basketball players.

Keywords: activity tracking, wheelchair users.

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Addressing Communication Issue Among Caregivers and Wheelchair Users: Identifying Design Metrics and Defining Needs

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Background: Needs for designing assistive technology devices (ATDs) are directly affected by variations in assistance required by the ATDs user, but people around ATDs user also affect definition of design needs as they interact with users on daily basis. Thus, other than functional aspect of ATDs, social and psychological aspects also gain importance. Here, we address the issue of difficulties in face to face communication during the process of assistance, among caregivers (CG) and wheelchair users (WU). Previous studies addressing this issue present new technical tools like autonomous mobility systems or novel wheelchair controllers. However early on in the design phase, it is difficult to assess nature of design problem required to be solved – whether in form of an original design or as new addons. In this work we narrow down the key metrics within the requirement-space that establish good correlations, focussing on improved communication experience and reduced stress for CGs.

Method: We conducted an exploratory study with a rehabilitation centre, and collected data in form of interviews and questionnaires with WU and CG (hospital staff and family members) as target participants. We designed a questionnaire targeting WU's activities, CG's workload, type of ATDs used, device handling problems, communication methods used and communication limitations. The collected data was analysed to narrow down relations among defined metrics statistically and qualitatively. The first phase of data collection and analysis lasted 1 month, establishing exhaustiveness of the designed questionnaire. 5 CG and 7 WU (5M, 7F) with mean age of 45.6 years (SD = 10.2) with mean experience of caregiving/receiving 4.58 (SD = 1.16, on a scale of 0–5), participated at first phase. CGs reported to provide assistance to 15.08 (SD = 10.99) wheelchair users daily, approximately 8.9 times (SD = 4.31) per day.

Key results: Significant correlations among CG's *duration to get tired* and *frequency of assistance* being provided were observed, e.g. +0.967 for night time all week, +0.893 and +0.898 for weekday and weekend afternoon time. Using factor analysis (FA) we grouped WU' activity and established differences in three components: *personal-amusement* (watching TV/reading, time with family), *task-activities* (going to shopping/hospital, playing indoors) and *daily-necessities* (toothbrushing, changing clothes). Also, using FA we narrowed down device handling problems to two components: *mediated-non-mediated* problem (passing through gates, static to dynamic) and *device-usability* problems (power needed, ease of rotation). Results pointed out communications among WU and CG happened mostly at start of the assistance activity ($\sim$ 40%), where CG were dominant through *speaking* and *touch*. CG faced moderate difficulty with WU's *voice* and *head-movement*, and high difficulty with CG's *bending their body* for communication.

Conclusion: The analytical study helps to narrow down needs in form of correlated design metrics for WU-CG communication, and targets enhancing the communication experience. This serves as the first step to establish novel concept designs to intangible problems related to ATDs like wheelchair. The sample size needs to be expanded further to generalise the findings. The future prospect for this work is to generate and analyse design concepts, and evaluate them based on the established co-related design metrics.

Keywords: communication, caregivers, mobility, wheelchair users, design metrics.

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Usability Assessment of a Navigation Tool for Manual Wheelchair Users in Urban Areas

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Background: Manual wheelchair (MWC) users have many challenges to overcome when traveling outdoors (slopes, thresholds, holes, sleepers, road works, etc.). They must experiment different paths to find the one that suits them best. Currently navigation tools are not necessarily adapted to the needs of MWC users. These technologies provide some information on the accessibility of service points such as stores, restaurants and etc. but not the accessibility of the road network. The development of an innovative navigation technology called MobiliSIG (mobilisig.scg.ulaval.ca), based on the wheelchair use confidence, made it possible to fill this gap by proposing a mobile application that can be used on different types of smart devices. The objective of this study is to assess the usability of MobiliSIG with potential MWC users. Usability is the degree to which a technology can be used to achieve specific objectives with effectiveness, efficiency, and satisfaction.

Method: Three men and three women (age: 26–52 years; MWC experience: 5–36 years; MWC skills: 22–91%) participated in an experiment on two distinct routes in a district of Quebec City (Canada). They were interviewed to evaluate MobiliSIG according to 25 usability criteria. They had to express their responses using a scale between 1 representing 'not usable at all' and 5 'strongly usable'. Consistency between the level of the accessibility of each segment proposed by MobiliSIG and the objective evaluation of the participants (using a scale between 1–5 [1 representing 'strongly disagree' and 5 'strongly agreeing']) was also assessed. A quantitative and qualitative analysis of the data highlighted the advantages, disadvantages of the functionalities of MobiliSIG and several improvements were proposed.

Key results: The overall average of the ratings obtained for the usability criteria is high ($4.1 \pm 0.6/5$). The top five criteria are: everyday vocabulary, ease of learning, endurance, assistance and support, and time spent for waiting. The five lowest rated criteria are: appearance, evidence of control, expected functionality, efficiency and effectiveness. The level of the accessibility of the segments according to MobiliSIG and that perceived by the participants are coherent 57% of the time (41 on 72 analysed segments of routes). For other segments, the level of perceived difficulty was higher for 20 segments and easier for 11 segments.

Conclusion: MobiliSIG is a promising tool for MWC users who want navigating in the City. This first iteration of MobiliSIG's usability assessment was generally positive. However, few points that will guide the future developments of this navigation tool were identified. Many technological challenges remain (e.g. improved positioning of the user, automation of the accessibility information extraction, considering changes in the environment and improved assessment of the accessibility) and should be considered for future development. As other perspectives, MobiliSIG should also be developed to include other profiles than MWC users, for instance, individuals who use other mobility device, blinded persons, etc. It should also integrate other modes of transportation for a complete trajectory, such as public transportation (e.g. bus and tramway).

Keywords: manual wheelchair, navigation, usability, effectiveness, efficiency, satisfaction.

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Technology and Disability 31 (2019) S133–S136
DOI 10.3233/TAD-190007
IOS Press

Part 4: Sport

Designing High-efficient and Easy-to-wear Thermal Interface for Cooling of Wheelchair Athletes During Training

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Background: Heat accumulation is a well-known bottle neck of sport training for wheelchair athletes with cervical spinal cord injury (SCI), whose thermoregulatory system has serious dysfunction. However, there is no definitive method to continuously remove body heat during exercise on a wheelchair. The authors have proposed a neck cooling belt that is wearable in a sitting position on a racer wheelchair. The belt has a tubular structure made of flexible elastomer film, in which cold water is circulated. Although the positive effect of neck cooling during exercise was experimentally confirmed, the structure of the belt has not been optimized yet. In this study, two main components of the cooling belt, i.e. flow channel structure for water circulation and load-relief feature to reduce neck pressure due to tubing, were designed and evaluated in order to improve the usability.
Method: [Flow channel structure] For high-efficient heat transfer on the neck, the contact condition between the belt and skin is a key factor. The flexibility of the tubular belt changes depending on the film thickness, the pattern of heat seal and the inserts between the films for anti-obstruction. The influence and extent of these three design parameters were characterized by measurement of heat absorption rate (HAR) between the cooling belt and neck. [Load relief] Tubing from a coolant circulator hung on the wheelchair backrest to the cooling belt can cause unpleasant pressure on the neck during propulsion. To relieve this load, a shoulder strap was designed and prototyped. Considering usability for handling with paralyzed upper limbs, loopless and one-side structures were tested with measurement of pressure between the belt and neck skin.
Key results: [Flow channel structure] The comparison among elastomer films with the thickness of 100, 200, and 300 μm showed that the decrease of HAR was measurable with 300-μm one. The decrease of HAR was also observed to be induced by the heat-sealing pattern at the middle of the interface, which reduces the real contact area between the cooling belt and neck skin. Both patterned heat-sealing and the array of flow channel inserts were effective for anti-obstruction of cooling water when the belt was tightly worn for good contact to skin. With these results considered, the cooling belt made of the 200-μm film which has the insert array achieved HAR of 20 W with the cooling water of 18 ˚C in a hot environment of 31°C. This HAR is almost twice as high as that reported previously. [Load relief] The measurement of the contact pressure between the cooling belt and neck skin showed the one-side shoulder strap caused unbalanced load on the neck due to its asymmetricity. The loop-less structure on the shoulder successfully relieved the load on the neck.
Conclusion: A neck cooling belt was designed and tested for thermoregulatory assist of wheelchair athletes. The parametric experiments quantified the relationship between HAR and flow channel structures and the effect of the loadrelief structure. The cooling belt with the optimal design achieved HAR of 20 W in average.

Keywords: Thermoregulation, Heat transfer, Neck cooling.

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Thermal characterization and field trial of a wearable coolant circulator for assist of thermoregulation in wheelchair athletes

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Background: Persons with spinal cord injury (SCI) have serious dysfunction in the thermoregulatory system. The loss of thermoregulatory responses in a hot environment, including sweating and vasodilation, sometimes leads to fatal incidents during intensive exercise. To overcome this problem, we have developed a thermoregulation assist system for wheelchair athletes. In a laboratory setting, neck cooling with a tubular belt in that cold water was circulated successfully suppressed the increase of core temperature in the subjects with cervical SCI during arm cranking. However, the effect of neck cooling in a real outer environment has not been demonstrated. In this study, we designed and prototyped a wearable coolant circulator that can be installed on a wheelchair. The thermal performance of the system was, then, characterized with benchmarking. Lastly, the system was used by wheelchair marathon athletes with cervical SCI under measurement of body temperatures.
Method: [System design] The coolant circulator consists of a Peltier device (max. heat absorption rate = 40 W), axial-flow pump, water reservoir, battery, and tubing to the neck belt. The size and weight of the system are 300 (W), 200 (H), 100 (D) mm and 2.9 kg, respectively. To reduce the system volume, the water reservoir and the fitting components of tubing were specially designed and made by a 3D printer.
[Thermal characterization] The heat absorption from the neck belt and the environment into the coolant were measured by precise thermistors in an artificial climate chamber of 31°C. The power consumptions of the Peltier device and the pump were also monitored in order to estimate the coefficient of performance (COP) of the system.
[Field trial] Two wheelchair marathon athletes were recruited as subjects of the field test. During running on the track on racer wheelchairs, the neck skin and core temperatures were monitored with and without cooling. The procedure of this trial was approved by the IRB of the National Rehabilitation Center for Persons with Disabilities, Japan.
Key results: [Thermal characterization] The maximum and average heat absorption rates at the neck were 48 and 15 W, respectively. The heat loss out of the reservoir was 5 W, while that out of the tubing was lower than the detection limit. Consequently, COP of the prototyped system was estimated at 40%. This value is as high as that of the previously reported wearable cooling device.
[Field trial] During the 45-minute trial with cooling, the temperature of the skin above the carotid artery reached around 28.6°C, and was 5.7 ˚C lower in average than that in the non-cooling trial. The decrease of the core temperature by cooling was observed in one subject.
Conclusion: A wearable coolant circulator for neck cooling of wheelchair athletes was designed, prototyped and evaluated. The system can be installed on a racer-type wheelchair, and showed COP of 40% with the mean heat absorption rate of 15 W. Cooling with the proposed system will be helpful for wheelchair users in outdoor activities as well as wheelchair athlete engaged in various types of sports.
Keywords: Neck cooling, Peltier device, Hot environment, Spinal cord injury, Wearable equipment.
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Automatic Production System for Sports Program with Support Information

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Background: For deaf and hard of hearing people viewing sports programs, commentary by Japanese Sign Language (JSL) helps them fully understand the situation of the game. To produce sports program with JSL is required the expertise in each sport to translate Japanese into JSL, and multiple interpreters need to stand by because the game mostly lasts for hours. However, the shortage of interpreters specialized in sports have become a barrier to increase the number of sports program with JSL. In order to solve these problem, we have developed an automatic production system for on-

line distribution. When the situation difficult to understand without audio information such as penalty occurred, the system provides the detailed commentary by JSL computer graphics (CG) animation and subtitles in real time.
Method: The system automatically renders JSL CG animation from prepared templates of JSL phrases corresponding to fixed format match data distributed during sports game. Extracted items from match data such as players' names, scores, and penalties are inserted into templates of JSL sentences. After this, JSL CG animation is rendered automatically from completed sentences and JSL motion capture data that recorded phrase by phrase. The rendered JSL CG animation is outputted with Japanese subtitles and score information to the screen for each event. That screen output is overlapped with the game video sent over the Internet Protocol (IP) network and distributed as one streaming video. Finally, the live video stream is played on a web browser. The video player on a web browser has the push notification function that pops up text message on the game video area to alert the penalty event. If user clicks the pop-up text, the JSL video explaining that penalty in detail is automatically played. We also developed a video on demand (VOD) player diverting video generated by live streaming process. The VOD player has a seekbar with event icons referring to time-series event list automatically generated form match data.
Key results: We have confirmed that the system could render JSL CG animation and distribute overlapped video stream in real time. Compared with the previous method that needed time required to generate MP4 video files of JSL CG animation, about 30 seconds delay time from event occurrence to JSL CG animation display was decreased. Furthermore, the system could also adjust the synchronization between game video and JSL CG animation by giving buffer time to IP game video stream. Although the user needed to seek the specific scene by themselves when using previous VOD player, the new event timeline helped user to playback the scene for each event efficiently.
Conclusion: To improve the viewing experience of deaf and hard of hearing people, we have developed an automatic production system. The system enables to generate JSL CG animation, subtitles and score information automatically and distribute game video stream with that support information. As a result, sports programs with support information are produced without human resources. We will verify the effective support information and provision timing while applying our system to the various types of sports events.

Keywords: Japanese Sign Language, Computer Animation, Sports.
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First Evaluation of Information Support of everyone by everyone for everyone TimeLine (ISeeeTL) applied to Deaf and Hard of Hearing People Watching Sport

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Background: Information support for deaf and hard of hearing (DHH) people usually requires hearing people to provide support to DHH people. Information Support of everyone by everyone for everyone (ISeee) is a project that uses crowdsourcing to generate information support in which the support-giving role is not fixed; DHH people provide information based on their abilities and knowledge for hearing people and vice versa.
We are developing an ISeeeTimeLine (ISeeeTL) system which uses crowdsourcing to make watching sport more enjoyable. To find out what is required to enjoy watching sports (including parasports) with the ISeeeTL, we conducted experiments in which both hearing people and DHH people watched sports. The results focus on the DHH people because all the students we teach at a department of Tsukuba University of Technology are DHH.
Method: The ISeeeTL is a website (rather than an application) for posting about sports rules, results, teams, etc. It bears a slight resemblance to SNS applications like WhatsApp, but the ISeeeTL allows the posting of temporary comments besides posts. All the posts appear quicker than those on Twitter.
Fifty eight participants filled in questionnaires after each of the five games, 18 of whom were DHH people. There were 1852 posts, 349 of which were submitted by DHH participants. It took 456 minutes to watch the games. For some questions, they rated from one (strongly disagree) to 5 (strongly agree). We used the responses to find out whether there were any differences between the opinions of the two participant

groups (DHH people and hearing people) and how ISeeeTL was appreciated when people were watching sports.

Key results: The questionnaires included three rating questions about reading the posts and four questions about writing the posts. We analyzed the answers to those questions with a two-way analysis of variance (ANOVA) in which the factors were the two participant groups and the questions.

The responses to the questions about reading posts showed there were significant differences between the groups ($p = 0.02$) and the questions ($p < 0.01$). DHH people evaluated reading posts better (mean 3.74) to hearing people (mean 3.36). The multiple comparison showed that the difference lies between the question on the usefulness of posts and the two questions on the quality and quantity of posts.

The responses to the questions about writing posts showed no difference between the two groups and a significant difference between the four questions ($p = 0.01$). The multiple comparison showed that the difference lies between the level of enjoyment from posting and those of the other three questions on burden, achievement, and importance of posting.

Conclusion: Though the current iteration of the ISeeeTL has received a positive evaluation on reading and writing posts, closer investigation shows that post quality and quantity should be improved. We are currently redesigning the ISeeeTL, and we are going to invite sports specialists to post valuable information.

The ISeeeTL has been officially approved as an information support system at some games of the National Athletics Meeting of Japan, including the wheelchair basketball games in 2019.

Keywords: Deaf and Hard of Hearing, Information Support, Sports Watching, TimeLine, crowdsourcing.

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Technology and Disability 31 (2019) S137–S146
DOI 10.3233/TAD-190008
IOS Press

Part 5: Communication

A Machine Learning Assistive Solution for Users with Dysarthria

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Background: With the rapid advancement in virtual assistant technology, many human computer interfaces exploit automatic speech recognition (ASR) solutions to get a verbal interaction with smart devices. Nowadays, such interfaces meet the demands of users without speech disabilities, while those with dysarthria, i.e., a neuromotor speech disorder leading to a poor intelligibility of user's speaking, cannot benefit from these services due to their communication disorders. Dysarthria condition is also characterized by an extreme variability of the speech (inter and intra speakers) and it occurs with severe motor disabilities. Therefore people with dysarthria and reduced motor skills are unable to use their speaking to make easier their interaction with computing devices, for example in smart home scenario.
Method: To address the aforementioned issues, we employ machine learning technology in order to recognize speech commands (keywords spotting tasks) in dysarthric speech. Our effort is to build ASR models based on deep neural networks, we intend to collaborate with people with communication disorders who wish to share their utterances in order to train such models. To this aim, we have developed a mobile app allowing end users to record their speaking while they pronounce given speech commands. Several application scenarios may benefit from our speech model. For instance, we currently work on an accessible smart home control especially designed for people with dysarthria, by integrating our custom keywords recognizer with openHAB, an open source software framework for smart home. With this solution, users with dysarthria can use personalized keywords to perform basic actions within their smart environments (such as controlling plugs or TV).
Key results: With the collaboration of four native Italian speakers with dysarthria, an initial dataset for training has been achieved including a small vocabulary (n.11 Italian keywords). By using Google's Tensorflow running on a GPU-enabled machine, a convolutional neural network model has been trained, it comes with two convolutional layers and a softmax classifier. In this early stage, we performed 18.000 training steps, and every 500 steps, we run a test on a validation-set. After the training stage, the same collaborators with dysarthria have been also involved into testing activities, aimed at recognizing given keywords in their utterances: our model showed acceptable accuracy level (58%) for 11 labels. This method is not tied to a given language, we plan to extend it in a multi-language way.
Conclusion: In the field of artificial intelligence, we present an ASR system for users with dysarthria. The machine learning approach is designed for detecting just a few number of predefined keywords within a reduced vocabulary. Initial experiments showed promising results thanks to a dedicated training procedure based on TensorFlow framework. In future works, we plan to better investigate the proposed application with the collaboration of many people with dysarthria who wish to share their utterances.

Keywords: Automatic Speech Recognition, Machine Learning, Speech, Dysarthria, Smart Home.

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Development of controllable electrolarynx controlled by neck myoelectric signal

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Background: Presently, there are many patients who lost their voice caused by laryngectomy, laryngeal injury and so on. The voice is very important communication method for human, and when the voice was

lost, the patient often causes the mental distress. For these patients, the research about speech production substitutes are implemented. However, they have problems with regard of voice quality, articulation, and intonation. For example, the electrolarynx has good features of voice continuity, sound volume and acquisition. However, it has poor voice articulation because of its uncontrollable pitch frequency. To solve this problem, many researches about the control method for electrolarynx are being conducted. All of these techniques focused on controlling the pitch frequency. Our research aims to realize the electrolarynx with high-level controllability. We focused on using the myoelectric signal of the sternohyoid muscle (SH) to control the electrolarynx. The SH has the function of vocal cords relaxation and activate during the utterance of low-tone voice. Therefore, the pitch frequency of electrolarynx can be controlled using the myoelectric signal of SH.

Method: Our proposed controllable electrolarynx uses the myoelectric signal measured by the myoelectric electrode attached to human neck near the SH. To get the stable signal, the grand electrode was attached to the wrist of the test subject. The measured signal is processed by a computer and outputted as the control signal. The most important thing is the determination of the parameter for conversion of myoelectric signal to control signal. From our previous research, it is confirmed that the exponent and quadratic are better than that of linear function. To evaluate the controllability of pitch frequency control, the indication of the subject's will was compared to the calculated pitch frequency and the errors were counted and calculated the error rate. The test subject indicated the indicators of "High", "Mid" and "Low" by mouse pointer with his intension. At the same time, he was conscious to generate the myoelectric signal, and the height indicator of pitch frequency lighted on according to the generated myoelectric signal. The errors were counted from captured video. The test subjects were 3 normal adult males.

Key results: From the averaged result of error rate, it was clear that the error rate of the linear relationship (22%) and the quadratic relationship (21%) are higher than that of the exponent relationship (13%). To evaluate the control stability, the numbers that the subject failed to keep the constant tone was counted. From this result, the numbers of failures of exponent relationship (1) was the least of that of other two relationship functions (7 each). Therefore, it was clarified that the best control function was exponent.

Conclusion: In this report, we proposed the control method for controllable electrolarynx using of neck myoelectric signal. From the results, it was clarified that there was an exponent relationship function between the RMS value of myoelectric signal and pitch frequency of vocalized sound. Using of this function, the controllability of electrolarynx was increased in the viewpoint of numbers of errors.

Keywords: Speech production substitutes, Electrolarynx, Myoelectric signal, Sternohyoid muscle.

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How do We Provide Necessary Support to Enable Remote Communication for People with Communication Difficulties?

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Background: To participate in today's society, one needs to be able to handle digital remote communication (i.e., communication with someone who is not physically in the same place). This includes phone calls, texting, e-mail, chat, social media, and other online services for communication. Use of remote communication may facilitate social contacts, self-determination, and participation. Unintelligible speak, in combination with difficulties in reading and writing makes remote communication difficult. Research has pointed out several obstacles to remote communication access, and users' right to communicate are not always being met. There is a need for increased support, but how this support should be administered has not been researched.

Method: The purpose of this study was to explore the need for necessary support to enable access to remote communication for people with communication difficulties. A qualitative design using focus group methodology was used to understand support persons' views and thoughts in their role of supporting users of remote communication. The participants were support persons to people with communicative and cognitive disabilities, which, at some level, interfered with using remote communication in daily life. They were family

members and/or staff who worked in sheltered housing, schools or as personal assistants. Five focus groups with 21 support persons in total were conducted. The focus groups were recorded and transcribed, and data was analyzed qualitatively using focus group analysis methodology.

Key results: The participants experienced a need for support for the users and their networks and identified it to be crucial in enabling remote communication for people with communication difficulties. They described a need for increased support on several levels. The users need lifelong support and individual training on a long term basis. There is a need for higher competency concerning remote communication among staff in the users' daily lives. There is also a need for better coordination between all different professional efforts and interventions. The support persons lack access to information about remote communication and technology and access to expert advice. They also pointed out that it would be useful to have all of the information in one place, suggesting that there should be a digital platform to gather all information about remote communication for persons with disabilities. This platform might contain instructional videos with tutorials, examples, advice, and recommendations by experts, and might also offer opportunities for people with communicative and cognitive disabilities, support persons, and professionals to share experiences and "life hacks." Further, it could also be a forum to connect with experts for online consultation.

Conclusion: Support is crucial in order to enable remote communication and participation in society for people with communication difficulties. Support needs to be provided on several levels; 1) Individual support to the user, 2) information and training for staff, 3) coordination of services providing support, 4) access to expert knowledge and sharing of knowledge. A digital platform with all supportive functions gathered is suggested.

Keywords: Remote communication, Social media, Communicative and cognitive disabilities, Training, Support.

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Let's Stay in Touch! Remote Communication for People with Communicative and Cognitive Disabilities

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Background: Remote communication involves communication between people who are not physically in the same place. Using everyday technology like smartphones, tablets and computers, including services for calls, messaging, video calls and social media are common means of communication in contemporary society. Digital communication is increasing as a required means of social interaction, communication for interactions for daily activities, like contact with healthcare, insurance or banks and, therefore, has become a prerequisite for participation in society. Despite this common use of the Internet and social media, several groups of people do not have access to remote communication. Being able to use remote communication requires either functional speech (phone calls and video calls) or the ability to read and write (texting, e-mailing or chatting). Several conditions, such as congenital, acquired and progressive disorders can affect communication abilities. People with a combination of communicative and cognitive disabilities may have limited speech and comprehension abilities as well as restricted reading and writing skills, which means that both their spoken and written communication are affected

Method: The aim was to explore and describe remote communication for people with communicative and cognitive disabilities in in relation to self-determination and participation from users', professionals' and support persons' perspectives. The research project is based on four studies: three qualitative (I, III, IV) and a mixed method (II). For study I, semi-structured interviews were used with seven professionals after an intervention project on texting with pictures and speech synthesis. In study II, semi-structured interviews with 11 users on their experiences of remote communication using Talking Mats, a pictorial communication tool. Study III and IV involved focus groups with 21 support persons on their experiences and views on remote communication for the target group.

Key results: Professionals described how text messaging with pictures and speech could increase independence and participation, and how individual assessments and user-friendly technology were important.

People with communicative and cognitive disabilities described how remote communication related to self-determination. Having a choice between types of remote communication and levels of independence was important, and technological limitations forced them to find their own communication strategies. Support persons discussed how remote communication enabled users to have more control and feel safer while increasing self-determination and participation. The results suggested communicative rights were not met, and there was a need for better provisions of technology and support.
Conclusion: Access to remote communication is crucial for participation in today's society where an increasing part of human interaction is carried out through digital channels. Access to remote communication can increase independence, self-determination and participation in daily life for people with communicative and cognitive disabilities. It can also affect health and safety. The findings suggest people with communicative and cognitive disabilities may encounter difficulties in accessing emergency calls and e-health services. There is a need for further technology development so that remote communication technology can be accessible for all. People with disabilities and their network need improved support.
Keywords: Augmentative and alternative communication, Assistive technology, Remote communication, Digital communication, Social media.
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Development of an AAC System for a Student with Speech Impairment and Spastic Quadriplegia

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Background: In complex cases of disability, custom Augmentative and Alternative Communication (AAC) Systems should be developed because existing standardized commercial products often leave user requirements unmet. AAC systems are personalized to reduce this mis-match between technology and user needs. A semi-custom solution was developed by Department of Industrial Engineering of the University of Naples Federico II, adapting commercial devices, 3d-printing mockups for evaluation and design new solution for assembly to wheelchairs. Several studies were conducted including: usability evaluation, learning curve rate, software and hardware optimization and cognitive assessment for actuators and layouts.
Method used: A custom system was developed for a student with complex communication needs caused by a traumatic injury that led to motor impairment and a speech disorder. A usability test and interface optimization are discussed to fix usability issues, highlight critical areas for improvement and design new prototypes. Performance, specifically learnability curves of the product were found. Learnability can lead to a reduction of design and product development times. Improvements in communication rate, number of operations per sentence, and errors were found. Additional central topics include areas lacking in current product development and methods of eliminating barriers to access.
Key results: A usability index was obtained from usability data. An Analytical Hierarchy Process and Multiple Criteria Decision Analysis are used to identify, prioritize, and investigate the usability functions in the product that can be improved. A learnability curve showing incremental of performance in a time of 8 weeks was also found.
Conclusion: Guidelines were developed through data collection and through decision criteria. The guidelines are generic and can be applied to usability heuristics. The main benefit of implementing Interaction Design (IxD), usability and ergonomics is the possibility to extend the results to other users through a parametric approach and generate generic-purpose tools and methodologies that can be applied more widely.
Keywords: Augmentative and Alternative Communication, User Needs, 3d-Printing Mockups.
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Augmentative and Alternative Gesture Interface (AAGI): Multi Modular Gesture Interface for People with Severe Motor Dysfunction

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Background: Individuals with severe motor dysfunction are unable to use existing computer interfaces due to spasticity, involuntary movements, and the like. The interfaces these individuals can use, if any, are limited to customized switch interfaces, which makes it difficult to operate a computer with any degree of ease. For individuals who can use only simple switch-based devices, these more sophisticated operations are all but impossible. It is very expensive to develop an interface able to respond to changes in an individual's movements caused by physical deterioration, so the main requirement is that it involve technology that can easily be customized for a diverse range of users at low cost.
Method: We have developed a switch gesture interface that utilizes a commercially available RGB-D camera. The system software recognizes gestures from 2D and 3D images, so the system can customize to each user easily than hardware systems. Furthermore, the software is easier to apply both daily and long term than hardware is. The 3D images can specify gestures by using shape information, thus enabling application to more varied environments and types of gesture than only using 2D images.
We used the RGB-D camera to gather data on the types of gestures that severely quadriplegic individuals want to use in an interface. The data included both moving RGB images and depth (range) images. A total of 211 gestures were collected from 55 individuals with motor dysfunction and the voluntary movements were classified on the basis of body part. We developed all algorithms for recognition in-house and used only a few basic camera libraries to obtain 2D and 3D images. If the RGB-D camera is discontinued, we can transport all software to another camera easily.
Key results: We developed seven recognition modules based on body part and two recognition modules independent of body part. Among the latter, the Front object module recognizes the closest region to the camera and is useful for movements of hands, arms, and toes, and the Slight movement module recognizes slight movement in the region of interest. We experimented on five testers with four recognition modules (Finger, Head, Foot, and Slight movement) in a long-term experiment (over three months). The user of the Foot recognition module is now using this system daily. Our original software and the RGB-D camera have been installed in the user's own PC, and he uses WORD and WEB browser by foot gesture every day.
Conclusion: To enable a low-cost interface, we have utilized commercially available RGB-D cameras and developed a non-contact, non-constraint interface. We collected 211 gestures from 55 individuals with motor dysfunction and classified voluntary movements on the basis of body part. We developed seven recognition modules dependent on body parts along with two independent recognition modules and facilitated long-term experiments with five users. For one user, we completely succeeded in practical use by foot gestures.
We call this software the Augmentative and Alternative Gesture Interface (AAGI) and will open it sequentially. All software will be supplied freely from our HP.
Keywords: gesture interface, support for the disabled, 3D image recognition, AAC, human sensing.
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Presentation Matters: A Design Study of Different Keyboard Layouts to Investigate the Use of Prediction for AAC

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Background: Augmentative and Alternative Communication (AAC) applications on mobile technology typically use on-screen keyboards for text entry. AAC users with limited dexterity tend to use single finger typing, leading to slow text entry rates. Although word and phrase prediction have the potential to increase rates, users tend to keep typing rather than selecting predictions. It is hypothesized that the need to scan lists of predicted words or phrases necessitates an undesired shift of gaze, resulting in missed predictions.
Method: We propose new ways for on-screen presentation of predicted words and phrases and report on early results from a multiple single user study using three different keyboard layouts. Keyboard layout designs were informed by a literature review, an online questionnaire and focus group activities with participants who use AAC. Three on-screen keyboards were implemented on a touchscreen tablet – a standard keyboard and two layouts which display predictions closer to where the user's visual attention is already focused. The Standard Layout (SL) displays a row of 4 pre-

dicted words above the keyboard; the 'Above Typed Layout' (TL) displays up to four predicted words in a 2 $\times$ 2 grid above the typed letter; while the 'Above Predicted Layout' (PL) displays up to 4 predicted words above the next predicted letters. Ten participants with neurological impairments affecting hand function were invited to copy type a number of short memorable phrases. All participants used single finger typing apart from one participant who used eye gaze with mouse pointer control for access. Due to physical limitations we were only able to record the gaze of four participants during their typing exercise using an eye gaze tracker. A semi structured interview was conducted after the activity. For the four participants with gaze data, we analysed text entry rate, error rate and personal preference using videos of the typing interaction, screen captures with gaze plots and verbal feedback.

Key results: Participants expressed different preferences of keyboards after the experiment. These ranged from preference for the standard layout (SL) due to the familiarity, to preference for PL due to perceived accommodation of finger and gaze movement. Entry rate was the highest using SL. Participants achieved the highest keystroke savings with PL and significantly lower savings with TL. Participants missed predictions using all layouts. Interview feedback conflicted with observed entry rates (e.g. preferring a slower keyboard layout, perceiving this to have a faster entry rate).

Conclusion: Preliminary results suggest that displaying predictions closer to the next letter to be typed may increase the selection of predictions. Although text entry rates were higher using SL, this may change with longer use of PL. Further studies which include the integration of phrase prediction into the PL keyboard and extended use are being undertaken.

Keywords: AAC, prediction, keystroke savings, communication rate, eye gaze

Acknowledgments: We thank Zulqarnain Rashid and Shuai Li for their part in coding the prototypes, Chris Norrie for data collection support, TobiiDynavox for supplying eyegaze technology and most importantly the participants of the study. This research is funded by the Engineering and Physical Sciences Research Council, Grant Ref. EP/N014278/1.

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Communication Partners' Perspective on the Use of an AAC Application Oriented to Just-in-time Language Acquisition

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Background: Visual aids, such as pictorial symbols and photographs, are widely used for exchanging messages between children and their communication partners in augmentative and alternative communication (AAC). A variety of AAC apps have been developed, but in many cases, the vocabulary should be selected prior to exposing the words to children. The selected vocabulary is often insufficient to respond to children's interests, needs, and actions as they arise during interactions.

Method: We developed a mobile application running on Android OS, named STalk2. It was oriented to "just-in-time" language acquisition. In other words, it was designed to increase the use of visual aids in the dynamic process of interaction between children and their communication partners. It is capable of recognizing voices and presenting visual aids stored in a local database and/or retrieved by an image search on the web; it also monitors communication activities. We conducted a longitudinal study (mean = 6 months, sd = 4 months) with 25 adults including parents, school teachers, and staff of after-school day service centers, and thirteen children with complex communication needs (CCN). In this study, the use of STalk2 in everyday communication was evaluated. At the end of the study, the adults completed a questionnaire consisting of ten statements. These statements were originally in Japanese, the native language of all participants. A five-point scale ranging from "strongly disagree" to "strongly agree" and an open-ended question to provide the reason were used for each statement. One of the statements was related to the overall satisfaction regarding whether needs were met using STalk2. The Spearman correlation coefficient was used to describe the relationships between the overall satisfaction and the responses to other statements. Statistical significance was set at $p < 0.01$.

Key results: The percentage top-two-box score, corresponding to those who agreed with the statement, for overall satisfaction was 50%. Responses to the following statements have strong relationships with the overall satisfaction: A) I thought the frequency of the child exhibiting problem behavior was reduced because he/she understood messages better (rs = 0.739), B) I thought the opportunities to present visual aids with verbal messages to the child were increased (rs = 0.660), C) I felt that the burden of communicating with

the child was reduced (rs = 0.576), and D) I thought the communication on which the child focused his/her attention was increased" (rs = 0.572).
Additional comments made by adults included, "the response time of the child for performing certain tasks was reduced and the child could express their own will," "the child could accept rescheduling because they could use STalk2 to confirm the information by generated speech to reduce their anxiety," and "STalk2 enabled me to rapidly search for and present appropriate illustrations."
Conclusion: The results suggested that STalk2 reduced difficulties for half of the communication partners of children with CCN by enabling visual aids to be presented during their conversation. By using STalk2, the partners presented visual aids more frequently, children with CCN focused on their communication and could understand messages better, and as a result, their problem behavior was reduced.
Keywords: AAC App, Communication Partner, Just-in-time Language Acquisition.
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AsTeRICS Grid – a flexible web-based application for Alternative Communication (AAC), environmental and computer control

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Background: In the field of Augmentative and Alternative Communication (AAC), there are several tools for the creation of layered grids, which show words and symbols and provide speech output. While most of these applications are designed for a single platform (e.g. iOS), in recent years also cross-platform web-based solutions emerged. Next to AAC functions, environmental- or computer control capabilities can be useful for the target audience of such systems. All currently available applications are either restricted to a single platform or miss extended capabilities beyond AAC. AsTeRICS Grid is a flexible system for the creation of AAC grids, environmental control solutions or alternative Human-Computer Interfaces, combining the advantages of existing web-based and native applications.
Method: The requirements for the communication-related features of AsTeRICS Grid were defined in cooperation with an AAC expert. Subsequently, the application was developed in multiple iterations (Kanban-based methodology), considering feedback by the AAC expert and students who worked with the application in the course of academic projects. A user study is planned for the near future. From a technical perspective, AsTeRICS Grid is a single page web application using various Javascript libraries. Native capabilities like environmental- and computer control can be added using bindings to the existing AsTeRICS framework (https://www.asterics.eu/get-started/Overview.html) as a backend. AsTeRICS Grid is hosted as OpenSource project on github.com (https://github.com/asterics/AsTeRICS-Grid).
Key results: Compared to existing AAC solutions, AsTeRICS Grid provides the following unique characteristics: (1) grid layouts and element sizes are completely flexible, (2) possibility of environmental- or computer control via the application, (3) platform agnostic web-application that is usable offline, automatically synchronizes the configuration across devices and at the same time maintains perfect privacy. Environmental- or computer control capabilities are realized using the AsTeRICS framework as an optional backend. AsTeRICS includes different sensor- and actuator plugins which allow a wide range of interaction capabilities targeting the native platform, including emulation of keyboard or mouse functions or control of external devices via HTTP, infrared and home automation standards. Selecting an element in the AsTeRICS Grid can e.g. trigger an action on a remote tablet, switch on lights or change the channel of a TV. Although it's a web application, AsTeRICS Grid can also be used without internet connection. Once the website was visited, the whole app is automatically stored locally using modern browser technologies and afterwards is usable offline. If users want to use AsTeRICS Grid on multiple devices, all configuration data can be automatically synchronized using the cloud, while the application remains fully functional without internet connection on each device. Data protection is guaranteed by implementing end-to-end encryption of all configuration data.
Conclusion: AsTeRICS Grid is a web-based tool for AAC that also provides environmental- and computer control capabilities and is usable across all major platforms. This facilitates new forms of usage which were not possible before: users can easily switch their preferred input device and control external appliances from the AAC application. Future research will focus on user-studies with persons who can benefit from these possibilities.

Keywords: AAC, Environmental Control, Web-based, Human-Computer Interface
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Attitudes and Usage of AAC in Bulgaria: A Survey among Special Education Teachers

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Background: Modern technologies for augmentative and alternative communication (AAC) form the basis for effective intervention for children with complex communication needs – children with physical disabilities, e.g. related to cerebral palsy, Rett syndrome, neuro-muscular dystrophies, but also children with autistic spectrum disorders or with intellectual disabilities. The knowledge and usage of AAC by the professionals working with these children is extremely important for the development of their full potential, their capabilities for communication and participation in social life. As Bulgaria is an emerging AAC country, in the paper we are interested in studying two main topics: the attitudes to AAC and inclusive education and the knowledge and usage of low-tech and high-tech AAC among special education teachers in Bulgaria.
Method: We developed a questionnaire consisting of two parts. The first part explores the attitudes towards inclusive education and attitudes towards using AAC. This is done by providing descriptions of children with 2 types of disabilities – severe forms of cerebral palsy (CP) and autism spectrum disorder (ASD). The second part of the questionnaire explores teachers' knowledge and usage of AAC (low-tech and high-tech) in their work with children with disabilities. The questionnaire is filled in by 88 special education teachers from Bulgaria. Data is collected anonymously using paper-and-pencil questionnaires.
Key results: The results from the questionnaire show positive attitudes towards using AAC by children with disabilities. There are more positive attitudes towards low-tech AAC compared to high-tech AAC. With regard to the attitudes towards inclusive education, the ratings are not so positive. Also, special education teachers rate specialized school as more appropriate (compared to inclusive education schools) for children with severe forms of CP or ASD. The results however show very low rates of knowledge and usage of AAC. Forty-six percent of the special education teachers in Bulgaria are not familiar with low-tech AAC methods and only about 30% of them use low-tech AAC. For the high-tech AAC the results are the even more disturbing. More than 2/3 of the professionals have no knowledge about text-to-speech software and less than 10% use it when working with children with special education needs. Alternative access methods are unknown to 85% of the special education teachers and only 2% use such assistive technologies for children with disabilities.
Conclusion: The results of the survey show alarmingly low levels of knowledge and usage of AAC among special education teachers in Bulgaria. In the same time, the attitudes about using AAC are mainly positive. The obtained results are used to formulate steps for overcoming the existing barriers in the usage of augmentative and alternative communication in Bulgaria: raising the awareness about the benefits of AAC; providing information about low-tech and high-tech AAC and their benefits for children with disabilities; provision of training AAC courses for special education teachers both during their formal education and on-the-job training courses.
Keywords: AAC, attitudes towards AAC, AAC knowledge.
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Sign Language Recognition through Machine Learning by a New Linguistic Framework

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Background: We have developed Japanese Sign Language Dictionary System for several years. Because many Deaf are less intelligible to the written Japanese, when they want to find a proper sign for a Japanese entry word through the present system, they have a problem that the entry Japanese word is hard for them, in contradiction. They need a new system to solve the problem in the way that a Deaf user signs in front of the camera, the system recognizes and automatically it shows the candidates for the target sign as a thesaurus, or a Japanese translation.

Method: Our system learns signs through Deep Learning and it creates a learn model which constructs the sign recognition system. The model data collected were 101 signs in the vocabulary of Level 6 in Japanese Sign Language Proficiency Test which is widely accepted in the country. The 12 deaf and hearing informants of repeated the recording experiments for several times. The total number of the signing data was 7,763. OpenPose, the Skelton Models detects and represents human joints on single images. It acquires the vector data and all the data was filed by CSV format of the trajectories at X and Y axes which were recorded frame by frame. In the next the Neural Network Console (NNC) by SONY analyzes the data. Long Short Term Memory (LSTM) was also used. Briefly explained, the system analyzed the data of vectors through Deep Learning, being extracted from the signing video by OpenPose, and the accuracy of sign recognition was about 75% as a result. The solution to raise the rate was discussed.
Key results: Approximately 90% of the 7,763 signs data were taken as learning data and the rest were to evaluate the neural network. As result of cross validation, the average accuracy was about 75%. The false recognitions were analyzed and found the cause by similarity of the signs, and the remarkable joints were found.
Conclusion: The recognition rate is insufficient for complete machine translation but is usable for a dictionary, because our dictionary offers some candidate lexis which are to be selected by the user. We will expand the sign data in the future and we expect the higher rate by deep learning. In our project, we also propose some new sign linguistic constituents because we need new concepts to apply for an electrical process of sign language in an analogy to applying acoustics for phonology. We focused to the movements of signing which would be physically indicated by the trajectories and speed of joints of a body. The remarkable joints, an elbow and a wrist were found to behave an important role.
Keywords: Deep leaning, Machine learning, Sign language, Sign recognition, OpenPose.
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Access to Non-Verbal Aspects of Group Conversations for Blind Persons

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Background: Communication between multiple people talking to each other in person, like during face-to-face business meetings, does not only consist of the spoken language and therefore requires more than the auditory channel to fully participate. Blind people who take part in this kind of meetings rely on the other participants to explicitly speak out any important non-verbal cues, like deictic gestures, which has proven to be especially challenging in heated discussions as people tend to fall back to their usual behavior of using non-verbal communication (NVC) to support their arguments. Perceiving NVC is key to successfully follow and contribute, particularly in these situations. Nowadays, a quite large set of non-verbal information can be captured using different means, including video and body-worn-sensor based motion capturing. However, the bandwidth of how much information blind people can perceive is limited in comparison to sighted people due to the lack of the visual channel. Therefore, a careful selection of relevant information is necessary to avoid cognitively overloading the blind person.
Method: This submission will outline NVC cues found to be helpful for blind people during face-to-face business meetings. Throughout the research multiple meetings have and will be analyzed and interviews with people from the target group have and will be undertaken to iteratively develop an ontology of the relevant information space, clustering pieces of information, modelling relations between them and help to process this data in an effective and efficient way to display a personalized stream of information to the blind user.
Key results: Analyses of meetings and interviews with blind people show that NVC is crucial in conversations, especially if more than two people are involved. Outcomes suggest that there is a disparity between NVC cues blind people think are helpful during a first interview and after exposure to additional NVC cues. Observations show that the set of NVC cues perceived to be helpful is a very individual matter as well, pointing out the necessity of a highly customizable stream of information conveying NVC cues. Creating an ontology which describes the information space is a continuous process. At the time of writing, 15 cues grouped in 5 main clusters of information have being identified covering verbal communication, non-verbal communication, visual artefacts, digital artefacts as well as spatial information of physical objects. Especially spatial aspects and non-verbal communication and their relations, like deictic gestures, show great potential of enhancing a blind person's overall understanding of group conversations.

Conclusion: This research aims at identification of the information space relevant to blind people in group conversations. Non-verbal communication, spatial information and other subdomains linked to them show great potential to significantly improve the overall understanding of group conversations for blind people, which is a crucial prerequisite for effective participation. Furthermore, a highly customizable approach to access this kind of information according to observation and interviews seems necessary as this is a very individual concern and decisively varies from person to person, depending on their capabilities and experience with this kind of information.

Keywords: Face to face Communication, Non-verbal communication, Ontology, Blind People

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Selecting AAC Apps for Effective Communication in a Mainstream Classroom Setting. A New Framework of Where to Start

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Background: Innovative technologies such as iPads and other mobile devices are changing well-established areas of experience and practice, including medicine, business and education. The field of speech language pathology is no exception. The accelerated rate of technological advancement is also affecting AAC as an area of study and practice. Current AAC assessment tools are not designed to address criteria for differentiating between AAC apps, leading most families and practitioners to download their selection without any robust guidance or assessment. This study looked to shift the focus from mere technology-orientated solutions to the key goal of enabling communication. Therefore, it is important to understand how these apps are initially recommended and obtained. It was necessary to gauge the impact this is having on students and those who support them. The three-year project aimed to empower family members and practitioners to differentiate truly effective AAC apps from the many others that proliferate in today's consumer-orientated market.

Method used: This project can be divided into key areas; Key Area 1: An environmental scan of current AAC assessment tools will be conducted to (1) evaluate which one(s) should be used to develop a tool for selecting among AAC apps and to (2) identify current barriers in app selection. Two online surveys were used to collect data from educators and practitioners, $N = 497$. The surveys consisted of both qualitative and quantitative questions focused on identifying the current usage of AAC, selection criteria, technical support requirements, perceived benefits and challenges from prior use of AAC. Four focus group sessions were facilitated with two for professionals and two for parents to gather further information and to gain an insight into how they currently select AAC apps and experience barriers in the app selection process. Two focus group sessions took place in the United States $N = 12$, and two in Ireland, with one for each group, professionals and parents, $N = 12$. Key Area 2: A formative evaluation of the results of Key Area 1 was conducted to develop the criteria that was used to guide the design of a new AAC app selection model to fit the consumer-orientated model we now find ourselves in.

Key results: The information gained was applied under Key Areas 1 and 2 to develop a consumer-friendly app selection tool that (a) helps potential users to identify potentially effective ACC apps and (b) assist them in acquiring the knowledge needed to overcome or bypass challenges to their effective use. To gain insight concerning its effectiveness, a participant feedback survey to obtain final feedback and direction for future improvements for this early prototype AAC app selection model was developed. The new AAC App selection tool is now available for use online – www.SelectingApps.com and is free to use.

Conclusion: Development of this new AAC App selection criteria will have fundamental and prevailing effects on the lives of individuals with complex communication needs. Furthermore, it will empower AAC users to reach their full potential by maximising their communication ability and participation in day-to-day life.

Keywords: Augmentative and alternative communication iPad Apps, AAC Selection, Communication Apps, (participation), (inclusion).

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Technology and Disability 31 (2019) S147–S154
DOI 10.3233/TAD-190009
IOS Press

Part 6: Rehabilitation and Assistive Robotics

A Custom Serious Games System with Forced-Bimanual Use can Improve Upper Limb Function for Children with Cerebral Palsy – Results from a Randomised Controlled Trial

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Background: Cerebral palsy (CP) is the most common cause of physical disability in childhood, with the condition affecting both motor and sensory function. Most children with CP favour their dominant upper limb during activities of daily living, resulting in a learned non-use phenomenon for their non-dominant (ND) limb, and consequently, decreased afferent inputs. The aim of this research was to design, develop, test and trial a custom serious gaming intervention to improve upper limb function, addressing both motor *and* sensory aspects of the limb, which was novel and had not been attempted before. The hypothesis was that sensory function could be significantly improved through regular use of a home-based haptic gaming system that required coupled bimanual integrated hand use to successfully play the games.

Method: The gaming system was developed using a stage-gate product development process for the hardware and an agile scrum methodology for the software. Universal Design principles, focus groups with children aged 4–16 years old, short-term in-home trials, and a co-design philosophy were adopted to produce the prototype system in 2.5 years. The system, known as *OrbIT*, is a standalone, self-logging, accessible and haptic serious gaming system that features 15 different games, which randomise game events to increase player engagement.

Eighteen children with CP (12 male; mean age: 10 yr 8 mo $\pm$ 3 yr 4 mo; *Manual Ability Classification System Level:* I(2), II(10), III(3), IV(3); CP type: hemiplegia ($n = 13$), diplegia ($n = 5$)) trialled *OrbIT* at home for 6 weeks. The *experimental group* ($n = 10$) received afferent haptic vibration to their ND hand via the controller, whereas the haptic feature was disabled for the *control group* ($n = 8$). Primary outcome measures were tests of sensation (pressure sensitivity, texture discrimination, distal proprioception, and stereognosis) and the *Jebsen Taylor Hand Function Test* (JFHFT). Assessments were conducted upon enrolment (A_1), immediately after the intervention (A_2), and 4 weeks post-intervention (A_3).

Key results: All 18 children completed the trial, with 2 children withdrawing post-trial. *OrbIT* was rated highly by families (7.4 $\pm$ 1.9 out of 10, median = 8.0, $n = 17$) and overall average system usage was 377 $\pm$ 267 mins, with no statistical difference in usage between groups ($p = 0.07$). Statistical modelling revealed a significant between group difference for the ND hand for the test of stereognosis between A_1 and A_2 ($p = 0.02$) that did not persist at A_3 ($p = 0.41$). When considered as a single cohort ($n = 18$), modelling revealed a strong statistically significant difference for the ND hand for the JTHFT total time ($p = 0.001$) between A_1 and A_3. However, a Type II error cannot be ruled out. A post-hoc analysis revealed an estimated sample size of 55 children for 80% power.

Conclusion: *OrbIT* proved to be an acceptable, feasible, and robust technology for children with both unilateral and bilateral CP, when upper limb sensory and motor impairments are present. Sensory improvements were recorded for the intervention group, but did not persist, whereas ND hand function improved significantly for all children post-trial. However, a larger and appropriately powered study needs to be conducted to validate the results of the trial.

Keywords: Serious Games, Universal Design, co-design, cerebral palsy, sensation.

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Ciranda: A Floor Seat Positioning System and Social Enterprise

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Background: One of the first challenges for many children with physical disabilities is to sit independently. A floor seating positioning system enables this milestone, helping the child to maintain eye level with other children, play and learn on the floor, rectify the posture and, as a consequence, helps including the child within its social spectrum. Ciranda is the first comprehensive floor seat solution to attend those needs in Brazil. The design aims to be safe, playful, affordable, and avoid negative connotations commonly seen on floor seat solutions, such as 'tightening' the child with straps or having an appearance of medical equipment. Ciranda design, inspired on cartoons, has an innovative adjustable looping system that hugs the child trunk to the backrest and a set of saddles on the seat that can adjust to different child' body sizes and shapes. The institute Noisinho da Silva, a non-government organisation, designed and produced the Ciranda seat for Brazil market and also developed the Oficina da Ciranda, a social enterprise service endorsed by UNICEF to accommodate the needs of parents in a vulnerable socio-economical situation by teaching them how to build their seat. These multi-awarded solutions had benefit more than a thousand children. Now, the institute is studying the applicability of the commercial solution within other markets and the social enterprise within other contexts. This research will focus on structuring the Ciranda project as a model that can be replicated in different regions.
Method: Ciranda and Oficina da Ciranda were developed as a result of a co-design between different stakeholders based on the principle of human-centred design. Anthropometric data were collected from 370 children who cannot sit without support, often children with cerebral palsy, myelomeningocele and multiple disabilities. The families of these children were visited, observed and interviewed. A project requirement was developed using the insights from the data, and a multidisciplinary team of collaborators were formed to co-design the solutions. For the social enterprise service, a model of collaboration was tested in a first workshop in 2007 and improved through the years. This research aims to study and adapt this model aiming to replicate the social enterprise in China and Hong Kong Special Administrative Region.
Key results: Oficina da Ciranda had already benefited more than 6000 people directly. This means that more than 1000 children with disabilities had their floor seating positioning system made by their community and family members, creating a network of people with similar values and struggles to support each other. The Ciranda commercial version was purchased by hundreds of families, contributing to promoting more Oficina da Ciranda workshops with part of the sales profit.
Conclusion: Ciranda project connects different stakeholders to form a community that supports each other and to build a solution for one of the many challenges a family with children with physical disabilities has. The model also unravels other challenges common to most assistive technologies, such as access to a device and training for the use and maintenance of the device.
Keywords: floor seat, positioning system, social enterprise, assistive technology service, design.
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Developing an Android Game for Restoring the Motor Functions of Fingers

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Background: Each year about 795 000 people experience a new or recurrent stroke. The number of the people involved in it is very high, and this number has increased fast. The speed of treatment has a large effect on the person's chance of recovery. The consequence of a stroke is a really serious problem, and it can make one's life harder. This is the reason why this application has been designed; to help people who suffered stroke to heal faster and go back to normal life sooner. There are promising interventions that could be beneficial to improve the aspects of gait including fitness training, high-intensity therapy, and repetitive-task training. Repetitive-task training might also improve transfer functions. Occupational therapy can im-

prove activities of daily living. Several large trials of rehabilitation practice and of novel therapies are underway to inform future practice. There is a wide range of methods, that can help the patients e.g. serious games for rehabilitation. The idea for developing a new rehabilitation game "Crafted Fingers" has been influenced by a game for children (http://www.fingers-in-motion.de/de/).

Method: We studied the most relevant scientific literatures. Based on the new results and on our earlier experience we have designed a new application for tablet, because we needed bigger surface and because of the touching function it was a good opportunity to combine the technology with the therapy. We used one of the most popular programming languages, the Java and we created the application for android platform. The "Crafted Fingers" application has 5 games: "Piano", "Memory", "Shopping-list", "Fly away" and "Drawing". All games need to be controlled by repetitive movements with fingers on the tablet or on smartphone screen. Every game has different difficulty levels. The "Crafted Fingers" have tested by therapists and elderly people. We measured the scores and time. The results will be shown at the conference.

Key results Playing this game helps everyday tasks become as easy as they were once. The different gestures help differently:

- Tweezer grip: help to pick up small objects,
- Selective finger touch: help in the typing (for example on the phone or on the computer),
- Rotation in the wrist: strengthens the wrist,
- Moving one finger: help the precision,
- Selective finger circles: strengthens the forefinger.
- Selective circles with the thumb: strengthens the thumb.

It will help more patients not just those who suffer from stroke, but those as well who somehow have lost their motoric function in their fingers.

Conclusion: This application will help to restore the motoric function of the fingers for those patients who use it regularly. Even though it will be successful, the patients need the traditional methods as well to achieve the best results during their rehabilitation.

- Benefits: easy to use, exciting, sustaining the attention, improve different skills.
- Disadvantages: It is not enough for the full recovery. It is not fully suitable to strengthen the muscle of the fingers.

Acknowledgements: The authors thank the financial support of Széchenyi 2020 under the EFOP-3.6.1-16-2016-00015.

Keywords: Android, Game app., Stroke, Rehabilitation, Finger motion.

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Hand Function in Skills of Modern Day among Elderly Individuals

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Background: Elderly individuals in the modern-day environment are obligated to interact with an ever-growing number of technological devices in order to participate in life activities and maintain their independence and quality of life. Operating such devices, such as touchscreens, requires the ability to perform unique motor skills such as tapping, swiping and virtual pinching. Hand function is subject to age-related change. Hence, studying the hand function abilities of the elderly during touchscreen manipulation is an important new research direction. The objective of this study was to characterize elderly hand function performance skills while operating a touchscreen.

Method: The study was a field study conducted in a community center. Study population included 28 community-dwelling elderly individuals (81.9 $\pm$ 4.2 years old) and 16 middle aged (53.7$\pm$ 6.2) adults. Data collected included subject's characteristics (demographic information, health status). Cognitive status was determined by the Montreal Cognitive Assessment questionnaire. In addition, functional mobility and dynamic balance was assessed by the "Time up and go test". Hand performance was assessed by a) Bilateral strength of hand grip and thumb-finger pinch grips (tip to tip, and three fingers pad to pad) using a calibrated JAMAR hand dynamometer; b) Manual dexterity by Functional Dexterity Test. A software appli-

cation called Touchscreen-Assessment Tool (TATOO) was used to measure hand performance abilities necessary for operating a touchscreen. Temporal and accuracy measures were collected while performing four of TATOO's tasks. Age effect was examined by comparing the performance of the two groups using the T test. $P \leqslant 0.05$ was considered statistically significant.

Key results: The elderly group were independent in basic and instrumental activities of daily living, presenting high level of functional mobility and dynamic balance as reflected in the TUG scores (10.3 ± 3.6) . However, the MoCA score for the elderly group (21.5 ± 4.3) revealed mild cognitive impairment of the individuals. The middle age group had no cognitive impairment (MoCA score > 30), TUG scores typical to their age (5.57 ± 0.95), and significantly lower than the elderly group. Significant age effects were observed in the grip strength, three fingers pad to pad pinch strength, and in manual dexterity. In contrast, no age difference was observed in tip to tip pinch strength. Touchscreen operating skills were significantly lower in the elderly, as reflected by the temporal measures and reduced accuracy in the TATOO's task performance. Interestingly, no age difference was observed in the "Pinch ability" task.

Conclusion: Significant differences were found in hand function performance of the elderly when compared to adults as reflected by traditional assessment tools and by TATOO's outcomes. However, the age-related changes are restricted to pinch skill, as shown in the tip to tip pinch strength and the "Pinch ability" task in TATOO that showed no significant difference between the groups. TATOO demonstrated the potential of becoming an important novel supplement to the hand function assessment toolbox to clinical professionals treating the elderly in the modern world. Future studies with larger samples are warranted in order to establish a normative dataset for the full characterization of hand performance while conducting a variety of touchscreen manipulations.

Keywords: Touchscreen Assessment Tool (TATOO), assessment; hand function, elderly.

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Mobile Health Game Development to Motivate Walking for Hematopoietic Stem Cell Transplant Patients

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Background: Fatigue is one of the most commonly reported symptoms for patients going through a hematopoietic stem cell transplant (HSCT) process. Physical activity (PA) has been shown to improve symptoms of fatigue in HSCT patients. The National Comprehensive Cancer Network Clinical Practice Guidelines for Cancer-Related Fatigue advise starting PA slowly and incrementally progressing with distance and time. The use of mobile device applications (apps) promoting fitness may be helpful in increasing PA. Our purpose is to develop a new fitness app called Walking Warrior (WW) for HSCT patients to be used as a step counter and a game.

Method: A game inspired by Candy Crush was ideated and designed as a matching puzzle game with the unique feature of walking to unlock new levels. The WW game play screen includes 10 different tiles, 6 displayed as a cell type, 2 as boosts, and 2 as blocks that make game play more challenging. Cell types include red blood cells, white blood cells, neutrophils, platelets, stem cells, and nerve cells. Each difficulty level has limited number of "moves" a player can make to reach the goal. Each level also has a different goal that the player must reach to get to the next level. The game contains bonuses for more points and obstacles for added challenge and diversity in game play experience. The step counter app tracks steps as the user walks. When the player reached the required number of steps, the game gives them one token and they can continue to play. We developed an admin page with a MySQL database and stored it on a server. Admins and authorized users can check how many tokens the user has and how many steps they made. Evaluating the usability of a game is an essential step in game design and development. Usability of WW and the step counter was assessed by domain experts (4 in game development and 1 in bone marrow transplant nursing). We designed and validated an item-response expert heuristic questionnaire survey/instrument with 40 items for evaluating and assessing usability of WW for

HSCT patients. Each evaluator rated the questions 1–5, where: 1 = strongly disagree, 5 = strongly agree.
Key results: Reliability analysis: Cronbach's alpha = 0.933, which indicates high reliability of the instrument. The findings from the heuristics questionnaire suggest that the game's assets of clarity, ease of use, appropriateness, quality, motivation, and mental effort were moderately favorable (> 3). Comments from experts propose that the game is causally fun, suitable for the target audience, and that the overall concept of the game is good with high potential.
Conclusion: WW could help many people who are fighting not just with cancer, but any disease, where physical activity is an important part of their recovery. Nonetheless, the treatment could be very exhausting for the patients. They must keep fighting as real warriors. Moreover, the game can be used by anyone who enjoys puzzle games or need motivation to walk.
Keywords: Serious game, Mobile game, HSCT patient, Physical activity, Motivation.
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Experience Level and Usability Evaluation while Using "TATOO", a Touchscreen Assessment Tool

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Background: Touchscreen devices are widely used in modern life therapy sessions. A touchscreen assessment tool (TATOO) was developed by Daniel-Saad and Chiari to provide valid and reliable data regarding fine motor skills while operating these devices. This tool fits individuals of different ages and varying abilities. TATOO consists so far of six tasks, each of which provides information on a functional component required when using a touchscreen, such as a tap, swipe, pinch, drag, and so on. A numeric and graphic report summarizes the performance of each task includes temporal and Kinematic aspects, touch pressure and accuracy.
TATOO was intended to be used by clinicians and by clients who are mostly without professional computer knowledge. For that reason, testing its usability is of paramount importance to predict the user's acceptance or rejection of the device and the degree of internal motivation to use it.
This paper reports a study that evaluated the usability of TATOO by both children with typical development and by clinicians. Furthermore, this paper shows the correlation between children's usability feedback and their level of experience to use touchscreen devices and also, the correlation between children's usability feedback and clinician's usability scores.
Method: Ten clinicians and 60 typical development children aged 4–10 have used this system in order to assess the usability of the tool. Clinicians were invited to the University of Haifa and given a three-hour presentation introducing TATOO and how to use it. Each of the clinicians was asked to assess six children using the TATOO application. After using TATOO, children evaluated their experience through the Short-Feedback-Questionnaire-Child (SFQ-Child), in which emoticons are used to describe the experienced level of difficulty. Usability Evaluation Questionnaire (SUS) and Semi-structured Interview were finally given to the clinicians. A demographic questionnaire was developed to gather data about the users.
Key results: The SFQ-Child questionnaire reached very high indices of pleasure (SFQ = 4.8 of 5 ± 0.49), comfort (SFQ = 4.65 of 5 ± 0.92), the sense of success (SFQ = 4.9 of 5 ± 0.53), and ease of use (SFQ = 4.7 of 5 ± 0.38). Clinicians rated TATOO's usability as "very good" (SUS = 85.5 ± 8.04, range = 70–97.5), which reflected their satisfaction with the system's usability.
We found no correlation between the clinician usability scores and the SFQ-Child, which means that the clinician usability did not affect the children's experience. Furthermore, there is no correlation between SFQ-Child and the variable "experience using tablet or smartphone" in the demographic questions, which means that children's experience did not affect their usability feedback.
Conclusion: TATOO will complement the 21^{st}-century assessment needs, where the traditional fine motor assessment tools are not able to capture the skills necessary to operate a touch screen device. The positive usability responses indicate that the new application has user-friendly characteristics and will likely have a successful use among the end users. Future studies with larger samples in different ages and with varying abilities are needed in order to update a new version with the universal design method.
Keywords: Touchscreen Assessment Tool (TATOO), Usability Evaluation, Short-Feedback-Questionnaire-Child.

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A Walking Assist Robot Which makes the Pelvis Move More Easily and Assists in Walking

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Background: One of the problems of the aged society is an increase in elderly people who have weakened muscle power. The most effective exercise therapy to counter physical frailty is walking accompanied by aerobic exercise. The walking assist robot in this research is designed not to rehabilitate frailty but to mitigate frailty for those elders who can walk by themselves. In other words, this walking assist robot does not improve the muscular strength of the leg, but is a robot that enables the person to walk faster.

Method: Our idea is that the walking assist robot can make the pelvis rotate more smoothly and to stimulate the sacrum which in turn enables a faster walking with a longer stride. Since the sacrum is located in the center of gravity in the human body, the robot makes it easier to rotate the pelvis by stimulating the right and left of the sacrum alternately according to the timing of the swing of the legs. The walking assist robot is composed of a pushing mechanism to stimulate the sacrum having one motor. When the pre swing stage of the lower limb is detected by the acceleration sensor attached to the thigh, a pushing stimulus is given to the right and left of the sacrum. The walking experiment was carried out in an 11 m length walking path by using a motion capture camera. We also conducted a SUS (System Usability Scale) questionnaire after the experiments. For this preliminary study, five healthy male student subjects were selected and measurements were done under the approval of the ethics committee of Osaka Institute of Technology.

Key results: Among the three prospective distances, i.e. 5 mm, 10 mm, and 15 mm, the best result was obtained in the case of the 15 mm distance. The highest performance for the timing of stimulation was observed at a time when the motor drive started stimulating while the leg was between pre swing and middle swing. As a result of the measurements using the motion capture, by increasing the extrusion amount of pressing stimulus, 3 of 5 showed an increase in walking speed, stride, pelvic rotation angle and the hip joint rotation angle. In the SUS questionnaire result of 6 items, the average was 59.5 points, which presents a problem concerning the complexity of the device.

Conclusion: It was our intention to develop a walking assist robot which would make the pelvis move more easily and assist people in walking. This robot will assist a person to walk more quickly using his or her own muscular strength without changing the strength of the person's own muscles. We believe we have introduced a novel means of improving pelvic rotation by pushing stimulation of the sacrum. As a result of preliminary experiments using healthy subjects, we hope that the effectiveness of this walking assist robot will lessen the effect of physical frailty for people in the aging population.

Keywords: Walking assist, Sarcopenia, Locomotive syndrome, Rotation of the Pelvis, Stimulating the sacrum

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VIVO-Rehab: Coupling Humanoid Robots with Motion Sensing Devices to Support Upper Limb Function Assessment of Children with Spinal Muscular Atrophy (SMA)

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Background: Emerging off-the-shelf technologies such as motion sensing input devices and social robots are increasingly used as assistive technologies (AT) not only to compensate for people's disabilities, but also to support health professionals in their daily activities in order to develop more enjoyable rehabilitation scenarios. In this contribution we report on the development of VIVO-Rehab, a platform for the supervision, monitoring, assistance and rehabilitation of users from their homes. VIVO-Rehab was pilot-tested involving three children with Spinal Muscular Atrophy (SMA) to doc-

ument the applicability of the platform in the evaluation of children's upper limb functions.
Method: VIVO-Rehab was designed to monitor pre-established parameters such as the analysis of movement for rehabilitation through the control of kinematic, dynamic and other physiological signals. The system integrates the Kinect device by Microsoft for Motion Capture and the humanoid robot NAO by Softbank Robotics. The NAO robot was used to instruct and demonstrate exercises. In this view, a set of predefined upper-limb movements was developed in collaboration with rehabilitation professionals involving elbow and shoulder joint movements. The set of upper-limb movements was then pilot tested with three children with SMA3 and SMA2 who were asked to perform movements shown by the Nao robot. During child-robot interactions, the Kinect recorded the data of the 25 joints. Subsequently these data were implemented in a Matlab program that allows the visualization of joints and segments during movement and allows the extraction of some parameters such as speed, acceleration and angles.
Key results: Observational results from the pilot study show that the use of Nao robot allows a greater interaction with children. Furthermore, the use of the Kinect allows to obtain good performances for the Motion Capture and with the Matlab program it was possible to perform both motion evaluations and the comparison between the movements.
Conclusion: This system can be applied both in the home and in the outpatient setting to perform continuous evaluations over time and monitor the improvement or deterioration of patients' movements. Future prospects see these devices implemented at home, useful for greater monitoring or home rehabilitation, so that they can easily see the results of the exercises performed or the correctness of the movements.
Keywords: movement detection, SMA, rehabilitation
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Socially Assistive Robots Influence for Elderly with Cognitive Impairment Living in Nursing Facilities: Micro Observation and Analysis

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Background: In recent times, the lifestyle of the elderly in Japan has changed considerably. While previously two or three households lived together, in general, now there is an increase in the number of lonely and elderly couple households. Furthermore, according to a Japanese government report, the number of elderly people with dementia, which was 4.62 million in 2012, is estimated to increase to 7.3 million by 2025. In this social context, using assistive technology to support the lives of the elderly can help them become more independent.
Method: Therefore, to observe and analyze the influence of social assistive robots on elderly people and nursing workers in a nursing care facility, a long-term intervention experiment was conducted from February 5 to February 25, 2018 (35 days), on ten elderly persons. The subjects' ages ranged from 81 to 97 years (Mean $= 89.4$, SD $= 4.81$). All the subjects (one male, nine female) could express their willingness to participate in the study, including those with mild cognitive impairment.
Key results: The findings showed that the number of dialogues and dialogue time vary depending on their cognitive function. While the average intervention was 6.4 the 1st week, 13.0 the 2nd week, and 17.0 the 3rd week in the group whose CDR $\leqq 1$, the average intervention was 2.6, 7.2, and 12.8 in the 1st, 2nd, and 3rd week, respectively, in the group with CDR $\geqq 2$. There were significant differences between the two groups ($p < 0.05$). However, the average number of dialogue times increased gradually in both groups in the intervention period. Also, in the conversation content analysis, it was found that the group with CDR $\leqq 1$ used more different kinds of words than the group with CDR $\geqq 2$. In addition, the average interaction time was 439.4 sec / week for the group with CDR $\leqq 1$, whereas it was 148.6 sec/week for the group with CDR $\geqq 2$. There was a significant difference between the two ($p < 0.05$). However, in the group with CDR $\leqq 1$, the average daily conversation time/week was almost the same, whereas it gradually increased in the group with CDR $\geqq 2$.

Conclusion: This could be attributed to the sound quality, pitch, and information presentation method of assistive robots using synthesized speech, making it difficult for them to be understood by elderly people with cognitive impairment. Therefore, correlating the frequency of artificial speech voice and degree of comprehension and cognitive levels is a future research subject.

Keywords: Socially assistive robots, Assistive technology, Elderly care, Human Computer Interaction, Sota,.

Acknowledgement: This research was supported by AMED (Agency for Medical Research and Development). This research was approved by the Research Ethics Committee of the University of Tokyo and Social Welfare Corporation Tokyo Seishin-kai.

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A Trial of a Communication Robot at Home for Elderly Living Alone Using Data from a telephone call beginning with "How Are You?"

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Background: The declining birthrate and longevity have become pressing issues in various countries including Japan. Effective sharing of health information regarding healthy elderly living alone is expected to extend healthy longevity by their own preventive health management, leading to significant improvement of the sustainability of health and economical systems. We have made calls with 168 elderly living alone for 8 years at regular intervals and collected the information which could be of use (CALL data), and supported them by sharing the information. To continue this activity, we planned a communication robot with the Question-Answer-Response format(QAR) via buttons. The aim of this study is to determine whether the robot can communicate with elderly people with fixed QAR without using the pattern matching technology.

Method: Using CALL data, the subjects to be discussed after many conversations was narrowed down to 30 items and 979 QAR were made and classified into three categories, namely, mundane topics (366 QAR), physical topics (291 QAR) and mental topics (322 QAR). We adopted a push button answering system for elders with feeble verbal communication due to aging and/or disease. These questions include ones related to day-to-day life as mundane topics, e.g. "How are you?", being asked at first, and then, problems associated with physical and/or mental topics, if any. Topics that they hoped for were investigated by repeated inquiries via buttons and thereupon advice could be provided. We conducted this two-way communication with general mundane issues at first, and then with specific ones by repeating QAR. Since the Profile of Mood States 2nd Edition and Short Form is used worldwide to estimate the psychological condition, our experiment is evaluated using POMS2-Adult Short. 13 participants (Average age:79.3) of elderly living alone (9/13 were targeted for "How are you?" calls) and tried the robot at home on a one-to-two-month interval, and the abovementioned information was examined to evaluate psychological effects in pre- and post-trial, and the willingness to possibly extend at the end of the examination. Tension-Anxiety (TA), Depression-Dejection (DD), Anger-Hostility (AH), Vigor-Activity (VA), Fatigue-Inertia(FI) and Confusion-Bewilderment(CB) were measured before and after the experiment. The rate of the improvement of the mood status was performed using paired t-study by TMD (Total Mood Disturbance (TA + DD + AH + FI + CB) – VA). Furthermore, their intention to extend use was investigated at the end of the experiment.

Key results: 13 participants showed statistically significant improvement in mood status during the experiment and 9 participants wanted an extention of the trial period. Furthermore, 13 participants were divided into two groups on the basis of the mean value of total TMD percent improvements: good improvement group (7 participants) and insufficient group (6 participants). The average age (Mean $\pm$ SD:83.3 $\pm$ 3.9) in the Good Group was significantly older compared with that of the insufficient Group (Mean $\pm$ SD: 75.2 $\pm$ 3.9).

Conclusion: The past eight years of our experiment have demonstrated that we can clearly identify the condition of the elderly living alone by asking only thirty questions with the help of our experimental communication robots.

Keywords: Communication Robot, Elderly Living Alone, Q&A Format, Chatbot, Tele-counseling database

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Technology and Disability 31 (2019) S155–S164
DOI 10.3233/TAD-190010
IOS Press

Part 7: Education, Learning and Intellectual Disability

Recommendations for Using Assistive Technologies for Inclusive Media Education in Kindergartens

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Background: The role of assistive technologies (AT) in inclusive media education is a rarely discussed topic because it is considered that the use of ATs in kindergarten is premature. The potential of digital media for the participation of children with disabilities is big, but there is no data on how to use ATs and the media in such a way as to increase accessibility for children with disabilities in kindergarten. Therefore, we aim to identify issues of accessibility of content according to the 'Doing Disability Concept', to identify ways in which identified problems can be solved using ATs and ultimately to give recommendation for use of ATs in kindergartens to solve identified problems.
Method: A team of 3 experts, working with children in a kindergarten has been formed. It was composed by the teacher, special educator, occupational therapist in order to create recommendations for the creation and use of ATs in the kindergarten. In Phase 1, team had to define problems of accessibility to the content/ activities. Seventy-two papers were reviewed, using the Doing Disability Checklist, for recording identified problems. In Phase 2, it was necessary to review papers which explains the ways in which the ATs solve the problems identified in Phase 1. Of the 92 papers reviewed, 7 were identified that meet the above criterion. Based on the review, the experts completed a list of recommendations for use of AT in inclusive media education in kindergartens.
Key results: In Phase 1 problems of accessibility of content are identified as: non-use or lack of adequate technologies to ensure accessibility; inadequate design of existing technologies used and digital divide; lack of IT education for teachers; lack of practical ways for inclusion; lack of motivation for children with disabilities to get involved; rejection by the peers. The results of Phase 2. indicated the positive role of ATs in addressing the identified problems: 1. Impact on the motivation of the child for participation; 2. Compensation of developmental difficulties facilitates the inclusion and prevention of digital divide; 3. Training is usually included when ATs are provided, which makes the problem of lack of teachers education solved.
Conclusion: Recommendations have been made for the use of ATs in kindergartens: Pedagogical staff should be technologically literate; When selecting ATs, make sure that all children can be involved in interaction through technology not only those with disabilities; Choose ATs which stimulate attention and child's play; AT should play a role in stimulating the development of skills, not only compensation; If technologies and media are not adapted for all children, make sure to use ATs or do not use technology at all. Include children in the design process of new ATs.
Keywords: Assistive Technology, Kindergarten, Inclusive Education.
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Creating Appropriate Instuctional Applications for Users with Intellectual Disability

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Background: Despite the abundance of literature in the area of human-computer interaction (HCI), there is limited HCI research about users with intellectual disability (ID).This research project evaluates Let's Stop Bullying, an eLearning application in development at

ISSN 1055-4181/19/$35.00

the Institute of Art, Design and Technology, Dublin, Ireland. This application aims to educate young adults with mild to moderate intellectual disability about bullying and cyberbullying. Cyberbullying is bullying, when perpetrated through technology.Understanding our participants' needs and observing their interaction, within a user-centred approach, this evaluation of a web-based instructional application informed the iterative process of development of an appropriate instructional resource intervention to educate users with ID. The aim was to design an accessible and user-friendly instructional resource to empower and educate about bullying and cyberbullying. Using audio, picture-based interventions, game-based learning and scripts, this study explores the level of user engagement with the application and the preferred method of learning for participants with ID.

Method: Purposive sampling was used to recruit participants of unspecified levels of ID. Recruitment was obtained in accordance with ethical standards of the Psychological Society of Ireland (PSI). Inclusion criteria specified an ability to communicate verbally and being over 18 years of age. These criteria were established due to lack of additional support from a speech and language therapist. Between five to eight users with ID have been suggested to identify up to 80% of interface problems. However, twenty-two individuals with mild to moderate intellectual disability took part in our focus groups and laboratory sessions over a three week period. Seven tasks were created to explore the application, with progressing difficulty to accommodate levels of ability through four modes of learning (game, video, audio, reading). The evaluation investigated preferred learning modes and engagement for this user group. The study employed a mixed-methods design including observational and inquiry methods of usability evaluation.

Key results: The 22 participants (9 = male, 13 = female), who took part in the study, were ranging in age from 19–34 years (M = 22, SD = 3.72). Their use of computers included smartphone, iPad, laptop and PC. Students indicated using the computer everyday (n = 14), once a week (n = 7), or once a month (n = 1). All participants indicated using a computer (n = 22) with varying frequency summarised below. Participants reported using the applications Snapchat, Facebook, WhatsApp, Skype, and Facetime. Of those that use Facebook (n = 12), 75% found it easy to remember their password (n = 9). Adapted System Usability Scale(SUS) self- report measures indicated that participants liked the Let's Stop Bullying application. The listening activity was the preferred learning modality, followed closely by the game activity. Indications are that participants would like to see more games and videos with people in the application. Observational analysis identified occurrences of positive and negative emotional engagement. Results revealed more positive emotional responses than negative emotional responses.

Conclusion: There is a lack of suitable instructional applications for users with ID. Understanding users' identified preferences informs the process of development to bridge this ditgital divide. This helps to create appropriate instructional interventions with value for users with ID, engaging them with educational technology.

Keywords: Intellectual Disability, Instructional Technology, Cyberbullying, Usability, User Engagement.

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The Contribution of iMovie Editing to Improve Storytelling Skills of a Student with Deafness and ADHD

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Background: This case study examined the contribution of video modeling and processing it, via iMovie editing, to promote planning and organizational skills in storytelling, of a student with deafness with Attention Deficit Hyperactive Disorder (ADHD), while describing his own personal experience in Sign Language. Deaf and Hard of Hearing (DHH) students with ADHD show lower test scores in assignments that require maximum utilization of executive skills, for example telling a personal story (Cannizzaro & Coelho, 2013).

In the past few years, researchers have been increasingly interested in the ability of DHH students to express their narrative. It has been found that students with deafness show lesser ability than their hearing peers in the structural aspect of the narrative discourse. Sometimes the difficulty stems from the differences between sign language and written language (Rathmann, Mann & Morgan, 2007).

Method: Manny is a deaf student with attention deficit disorder who studies in a special needs school. Dur-

ing a composition lesson, Manny was required to share his personal experiences with his classmates. This task was very difficult for him and his stories lacked in sequence. The rest of the students found it difficult to understand him and as a result their attention level decreased. When Manny noticed this, he would give up and return to his place. This affected his sense of competence and the level of participation in the lesson.
A qualitative approach to a case study was conducted. An intervention program was developed that integrates video modeling and video processing using the iMovie application. According to this method, Manny watched his video telling an experience story, then edited the video and finally watched it again so that he can learn what a correct narrative scheme is.
Key results: The findings show that the video Modeling served as a mirror for the student and reflected on his conduct during storytelling of his personal experience, to his classmates. In addition, as a result of the editing process, the student internalized the narrative scheme while maintains a temporal sequence and using connecters in a correct order. The processes indicates impressive progress of the student's of executive control of information and to his ability to initiate the editing process without the teacher mediation. In addition iMovie was found as an intuitive app for the student. It enabled him to implement the editing technique easily, thus facilitating the learning process of the narrative schema.The findings did not show the contribution to the student's planning and flexibility skills, nor to the extension of his attention range.
Conclusion: Children with deafness usually rely on their sight in order to absorb various experiences and information. Thus, watching his video before and after the editing process helped Manny to see easily where his difficulties lay and facilitated the learning process. Moreover, it helped him correct easily his errors, improving his control skill while internalizing the narrative schema. There is still a need for continuing practice in order to enhance the level of the story that is being told.
Keywords: Executive functions, Video modeling, Imovie, Storytelling, Deaf and Hard-of-Hearing people (DHH).
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Observation of HandiMathKey Appropriation Phase by Disabled Students in a Middle School

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Background: The mathematical input in text editors by disabled students is demanding both at the functional level (motor disorder) and at the cognitive level (attention, visual-spatial, memory) and generates fatigability little productive and effective gain. To reduce these demands, HandiMathKey, a mathematical keyboard software was designed by applying a user-centered method. The aim of paper is to report how different disabled students have appropriated HandiMathKey in a middle school by an observation carried out by a multidisciplinary team. The hypothesis is that HandiMathKey can be learned and used by all students with disabilities.
Method: A team (one mathematics teacher, one occupational therapy and one specialized education assistant) leads an interdisciplinary workshop to observe how the students accept and use HandiMathKey. This field study has started since September 2018 at the Jean Lagarde rehabilitation and education Center.The HandiMathKey was proposed to 23 students (19 with hand motor impairment, 3 with visual impairment and 1 other with dyspraxic and dysgraphic disorders) in three classrooms of middle school. Two classrooms use the HandiMathKey with the Microsoft Office editor, the third with the one Libre Office. Every three weeks for each class, a workshop takes place during the class time: the teacher introduces the HandiMathKey features corresponding to the mathematical concepts being taught; then the students are invited to do mathematical exercises and the occupational therapist may assist them in getting to grips with the HandiMathKey. During the workshop two types of data are recorded: 1) notes of teacher and occupational therapist within reflection diary; 2) activity log of the use of HandiMathKey. After five workshop sessions the students are invited to reply to answer a SUS (System Usability Scale questionnaire).
Key results: This study confirms the interest of having a multidisciplinary team for observation and assistance in the appropriation phase of HandiMatHKey. We report the five observations of 9 students with motor impairment. The students were all volunteers but during these workshops they did not seen the immediate interest of HandiMathKey. The students appro-

priate HandiMathKey due to the interface affordance. However, there is a need to learn how to use the LibreOffice text editor. The typing with HandiMathKey and LibreOffice is similar to reading the mathematical formula, which makes it more affordable for students with planning and visual-spatial difficulties. As the sessions progressed there is a greater participation of students.
Conclusion: This field study shows that the appropriation phase of HandiMathey is necessary for students to agree to use it as an assistive technology. Another perspective is to analyze the typing speed and the error rate.
Keywords: Mathematical Virtual Keyboard, Acceptability, disabled students, observation, education.
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Digital Assistive Technology Education and Training

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Background: Assistive Technology (AT) is, by its nature, interdisciplinary. However, education and training in AT is usually delivered within specialist programmes, e.g., in occupational therapy where AT is intrinsic to the delivery of services which aim to support independence and inclusion of persons with disabilities. With the increase in digital AT, there is a need to equip a wider range of professionals with knowledge and skills to ensure effective use of such technology. Training in digital AT and accessibility has been embedded into both mainstream undergraduate and taught postgraduate degree programmes in Computer Science at Dundee University. This study was conducted to identify the range and focus of AT training as reported in the literature, compared to that being offered in Dundee.
Method: A high sensitivity literature review was conducted to identify the nature and delivery of AT training. The Web of Science bibliographic database was used to identify published outputs using the terms: (assistive technology) AND (teaching OR learning OR education OR training OR instruction OR "professional development"). A total of 1,504 papers were returned. Examination of the paper titles revealed a focus on the teaching or instruction of users instead of professional education and training. The search was thus refined by using the following terms: (assistive technology) AND (education OR "professional development"). On inspection, 32 papers describing a range of AT education and training.
Key results: The papers described a range of education and training of AT. Some programmes were specifically designed to provide training to a multidisciplinary cohort of students at post-graduate level. Such programmes tended to be Biomedical with AT as a component, while some have focused specifically on AT, equipping students from both a technical and a clinical background to develop skills in the assessment and provision of AT. Training and awareness of AT was also provided within specialist professional training, e.g., teacher training and occupational therapy, although there is evidence that special educational teachers and therapists lack sufficient exposure to AT.
Conclusion: Most AT training and accreditation have a medical and healthcare focus. This may be appropriate for traditional AT which is dependent on biomechanical and electronic engineers to provide access to mobility (wheelchairs, prostheses, etc.) and aids for daily living (hoists, kitchen appliances, etc.). However, computer science and software engineering are now at the forefront of developing inclusive and accessible technology. Accessible mainstream computing and digital AT have the potential to enable people with complex physical and/or intellectual disabilities to access a wide range of activities including communication, education, employment and recreation. In order to ensure that the "digital economy" does not result in an ever increasing "digital divide", digital AT and accessibility must be embedded into mainstream software engineering curricula. It can be argued that instead of viewing accessibility as an 'optional extra', this area of technological design and application should be embedded into mainstream degree programmes, thus equipping software engineers to meet the needs of any individual, recognizing the natural diversity in all societies.
Keywords: Accessibility, Assistive Technology, Augmentative and Alternative Communication, Digital Assistive Technology, Higher Education, Training.
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A special Needs Course in Undergraduate Health Professions: An Evaluation Using Mixed Methods

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Background: Assistive technology as a strategy to improve functioning of persons with disability is commonly accepted as of high value. It is an area where different professional specialties converge (e.g. engineering and health), but the theme has a narrow presence in academic syllabus among graduation programs. Despite the impact of this strategy on the level of participation for people with disabilities, the fact is that health professionals still demonstrate a lack of positive attitude towards assistive technology and a lack of training for its counseling or prescription. The aim of this study was to evaluate the impact of the Special Needs Course (driven for assistive technology) in undergraduate students from the School of Health Sciences - University of Aveiro, Portugal. This course if framed by the International Classification of Functioning, Disability and Health (ICF) conceptual model.
Method: Sequential mixed methods were used based on the first three levels of Kirkpatrick Model of Training Evaluation. From the nursing graduation program, 32 students (26 female) and aged between 18 and 24 years participated in the first two levels of the study. For the third level four health professionals were recruited (three female), aged between 28 and 32 years and with more than five years of experience, who had attended the course during graduation. Concerning the first level of the Kirkpatrick Model ('Reaction'), the results from the questionnaire (comprising eight items; 1–9 likert scale, 9 = higher quality) used in Quality Management System of University of Aveiro were analyzed. The second level ('Learning') achieved by students was assessed using the pre- (day 1) and post-training (last session) test, containing five questions on the content addressed and five questions on contents not addressed but related to the theme. Finally, the third level ('Behavior') was assessed through a focus group. Data analysis included descriptive and inference statistics for the first two levels and content analysis for the third level.
Key results: The global median for 'Reaction' was Med = 7 (IQ1–IQ3 = [6.5–7.5]), with the highest values found in question about 'availability of study materials' and lower values found in 'articulation between the activities developed and the previous competences. The repeated Anova measures show a significant effect for the difference between pre- and post-training in addressed questions when compared with the difference for not addressed questions ($F(1,31) = 6.4$, $p < 0.05$). Focus group revealed: (i) the content of the course is considered important for those that work with persons with disabilities or elderly persons in community but less for those who work on hospital settings; (ii) ICF approach improves clinical reasoning for 'enabling' but professional contexts still show reluctance in adopting it as a framework for practice; (iii) a multidisciplinary approach should be implemented during practical classes.
Conclusion: The Special Needs Course is an applied model for integrating assistive technology in health professionals' education. Although the students reveal a lack of previous experiences in approaching these themes, the results suggest a good adherence and learning of the content addressed. The real impact of this course on professional competencies and consequently on health interventions should continue to be deepened.
Keywords: Special needs course, Graduation program, Assistive technology, ICF.
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The Impact of Using Learning Apps on Executive Functions: Task Initiation and Persistence of Students with Attention and Learning Disorder

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Background: The presentation will describe seven studies that have been examining the impact of using learning apps: iPad apps and learning software, to enhance executive functions: task initiation and persistence among students with ADHD (Attention Deficit Hyperactive Disorder), SLD (Specific Learning Disorders), and challenging behavior students, characterized with difficulties in emotional regulation.
Initiation and completion of academic tasks pose the most common difficulties for pupils with learning difficulties. Task initiation is defined as the ability to independently begin a task when someone wants or is instructed to do so (Anderson, 2002; Gioia, Isquith, & Guy, 2015). Task persistence or sustained attention

refers to continuous performance of a task without distraction in order to complete the task (Barkely, 1997). Difficulties in sustaining working memory have a negative impact on one's ability to remain attentive and focused for appropriate lengths of time (Isquith, Gioia, Guy, Kenworthy & Staff, 2008).

Method: Seven single-subject research design were used for this study. An ABAB design, with a withdrawal between Phase B1 and Phase A2, was implemented (Cooper, Heron, & Hewar, 2007; Kennedy, 2005).

Subjects span a range of backgrounds, including age, school, and different learning disorders: ADHD, challenging behavior students and students with SLD. Each individual is separately exposed to a series of lessons under controlled conditions (baseline) and a series of lessons under experimental conditions (intervention). The data provide a framework for describing the changes in the use of single-subject designs for each student.

Phase A was used to establish a baseline and to monitor the use of traditional materials, while during the intervention phase (B), teachers used a portable computer or iPad with learning apps, including camera and dynamic interactive games.

Key results: The graphed data indicated a clear difference between Phases A and B across all participants and across all variables. The means showed similarities within phases and a clear difference between Phases A and B.

The visual examination results suggest a decrease average of time response to the assignments (Task initiation) along with reducing the average number of breaks during the intervention phase (task persistence), when use a laptop or iPad with learning apps. Also, the changes in levels for all studies occurred immediately after the change in phases. Phase B2 level show stability in the graph variation and/or data reduce, for all participants.

Conclusion: Children with ADHD, SLD, and challenging behavior, have hard time to initiate tasks and keep attention persistence during learning assignments. The study indicates that using learning apps allows these students to engage their assignments and extends the duration of attention throughout the task.

Using learning apps along with assistive technology, helps raise children interest in learning, provides instant feedback, and increases the students' accessibility (as with reading software) to challenging material. When students succeed to accomplish tasks as a result of their hard work, they feel empowered as they recognize that their persistence will lead to improved academic performance (Meltzer, Dunstan-Brewer & Krishnan, 2018).

Keywords: Specific Learning Disorders, Executive functions, (Learning apps), (Task initiation).

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"ADAPEI transport": A Learning and Navigation App for Young Adults with Intellectual Disabilities to Improve their Autonomy to Take Public Transport

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Background: This project is done in collaboration between Altran and ADAPEI from Belfort (association for helping young adults with intellectual disabilities). Problems can happen to disabled young adults when they want to go from a departure point to the final point taking the public transport because of the complexity of the transport network. The aim of our work is to develop a learning and navigation app to improve their autonomy for taking public transport with a menu to save paths and another to navigate. In the state of the art, an adapted navigation app called Way2B has been found.

Method: Our app has been developed in an Android system. To create a path, all the peripheries of the Phone have been used: for example, the camera to take a photo from every landmark, the microphone to record the actions to do, the keyboard for typing the actions to do. Pictograms associated to the actions, the line, name and time schedules of the bus can also be added. GPS coordinates are also saved in every landmark. While saving the path, GPS coordinates are also recorded every second. This information is used to visualize sequentially, in a map the path done with the waypoints. Three main functions based on data fusion have been programmed to help the children:

- To prevent the child to press on the stop button in the bus

– To indicate the direction to take when they get off from the bus.
– To anticipate the change of directions in pedestrian navigation.

Tests were done with specialists who used the app for the first time to record 2 adapted paths. Additionally, 2 children with medium level of disability and medium experience taking public transport (always accompanied by a specialist) tested the functions of the app in 2 hybrid paths (bus and pedestrian mode) accompanied by a researcher and a specialist.

Key results: After using the app for recording a path with 4 steps and another with 8 steps, specialists think that the app is intuitive and easy to use and they can create adapted paths in a fast way.

The alarms for preventing to press the stop in the bus were understood by the children and automatically they pressed on the button. The information on the map like the current position and the arrows for turning right or left seem to be understood by the children after explaining them the meaning. While they were doing the pedestrian path we have asked them what actions to do when arrows appear and they answered correctly.

Conclusion: We have shown the efficiency of ADAPEI transport having encouraging results. It has been tested the efficiency in the creation of the path having good results and acceptance with new end users. Children have understood different information like alarms and images that appears on the screen during navigation confirming their accuracies. Future work will include adding information from bus time schedules in real time and more tests with children to validate the functions.

Keywords: GPS, bus, transport, navigation, intellectual disability.

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Assessment of SlideWiki OpenCourseWare Platform by Individuals with Mild or Moderate Intellectual Disability

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Background: The introduction of new software does not often take into account the opinion of people with intellectual disability (ID) and issues, such as accessibility, usability and inclusive design are often neglected or left out. The purpose of this research was to train people with ID in order to use the SlideWiki OpenCourseWare (OCW) platform and examine the extent to which it is accessible to this population. Recent research indicates that SlideWiki, which among others allows the creation of highly-structured remixable and easily shared OCW, is a promising addition in the field of web-based learning. However, specific adaptations are needed, such as easy-to-read description of the platform functions so as to be fully accessible to learners with ID.

Method: The sample of this study ($n = 10$) consisted of 4 women and 6 men with mild and moderate ID, aged from 20 to 50 years old, attending a vocational education and training center in Greece. The training and assessment period lasted from 6 to 8 weeks depending on the group of beneficiaries. The hourly training sessions took place from once to twice a week and occurred almost concurrently with the platform assessment. The training tools used were presentations uploaded in the platform in an easy-to-read format and an easy-to-read manual in printed form. Presentations created by the participants in topics that interested them were also used. The participants assessed the accessibility of the initial page and the easiness of the search function, the profile creation and signing in. They also evaluated their understanding of the text in the screen, the platform settings, the use of colors, text functions, pointer and other functional characteristics and they were able to manage their presentations. The trainers observed some initial difficulties in the handling of the platform by the participants, although eventually they became accustomed with some features of the new edition. In order to develop a more comprehensive understanding of the data, triangulation was used. The participants completed 3 forms at the end of the training period in order to record their exact opinions and facilitate the data quantification.

Key results: The different forms provided divergent results, regarding the accessibility and easiness of the platform. Moreover, the opinion of the trainers on how the beneficiaries perceived the use of the software was not always identical with the opinions recorded in the forms. The most important finding though, was that the beneficiaries prided themselves on working as a team and having their opinion taken into consideration.

Conclusion: The suggestions that were put forward by the beneficiaries are worth mentioning, as these could make the platform more usable and convenient to the people with ID. Some key suggestions include the

translation of the platform, the change in the appearance of certain functions (e.g. arrows, pointer) and the use of speech-to-text option which might be more convenient than text-to-speech specifically for this population.

Keywords: SlideWiki, Intellectual Disability, OpenCourseWare.

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Can Accessible Technology Help Person Centered Planning? Exploring the Role of an ICT Solution to Evidence Value in Service Delivery for People with Intellectual Disabilities (ID)

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Background: Under 'New Direction Guidelines' from the Health Services Executive (HSE) Ireland, there are pointers to how the implementation of a digital environment can support and ensure a more efficient and effective service. However, health and social service providers face persistent challenges such as budget limitations and inadequate staffing levels. Other challenges include compliance to national, and international regulations such as HIQA (Ireland) UNCRPD, Accessibility ACT and GDPR. All these affect the ability of services to invest in and manage digital environments required to support efficient and effective services. Saint John of God, Liffey Services have engaged in a pilot project with Asperico the developers of *iplanit,* a cloud based person-centered client management system. It supports person centered provision by keeping track of client's goals, focusing on outcomes and giving the user easy access to their information. The project builds on a previous one which explored how Assistive Technology (AT) can be used to support independent living and the adoption and development of accessible digital personal plans.

Method: The pilot project is complemented by a Strauss and Corbin's grounded theory study that uses an interpretive approach, underpinned by symbolic interactionism as the theoretical framework, to gain insights into the participants' narratives on how *iplanit* mediates person-centered planning. This qualitative study is split into three phases; i) desktop study phase with literature review, ii) pre-pilot interviews and, iii) a post-pilot focus group discussions. The pre-pilot interviews were carried out between May 2018 to April 2019. A total of 34 participants were interviewed for phase two including 12 persons with ID, 6 family members, 10 support staff, 6 management and community members.

Key results: Data analysis found that accessible digital personal plans facilitated plan owners to feel empowered, and a sense of ownership over their information and plans. iplanit has provided better accessibility to relevant information for all stakeholders. It gives the plan owner autonomy over the development of their plans, a direct say in what they would like to achieve evidenced through the use of accessible multimedia. For service providers, the system provides an accessible platform to evidence personal plans, related activities and outcomes. Findings also indicate reduced need for administrative resources compared to paper-based planning. It supports the move to community service provision. There was also evidence of improved information sharing and access between relevant stakeholders. Used effectively, iplanit can improve accountability for staff and management and provide value for money evidence in investing in digital solutions.

Conclusion: Accessible digital solutions can support person-centered planning and improve service efficiency and effectiveness if the solutions are co-designed with relevant stakeholders. However, co-designing digital solutions can be challenging. Technology developers can be reluctant to provide the necessary built-in assistive technology needed to ensure that all stakeholders can engage in the solution. Issues of copyright and public good versus profitability can also be difficult to manage in co-design processes. Further research is required to explore how best to involve people with ID and different interest stakeholders in co-design of digital solutions.

Keywords: Person Centered Plans, Accessible Technology.

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Evaluating a Social Inclusion Intervention with Support of a Mobile Application among Young Adults with Intellectual Disabilities

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Background: Social inclusion has been regarded as a key outcome in the general health of all individuals and it has been reported to have a number of benefits, particularly for young people with intellectual disabilities (ID). Research on social inclusion and the use of digital technology among young adults with ID are reported to play a vital part in how they can connect socially. Too often, young people with ID are excluded from taking part in social activities because they struggle to understand social cues and respond appropriately. Therefore, this pilot study investigated a social inclusion intervention with the support of a mobile application to improve social interaction skills for young people with ID.
Method: A pre-post study design was adopted to evaluate the implementation of a social inclusion intervention with the support of a mobile application. In addition, three social validity questions were included at the end of each social activity that was uploaded on the mobile app. Ten participants with ID, 18 years and older, participated in a weekly intervention session using the mobile app over a period of 12 weeks. Participants were recruited from four institutions that provide day services to people with ID. Seven staff members participated with the service users to implement the intervention. The staff completed six intensive training sessions on how to use the mobile app. Parents, the ten young people with ID and staff provided input on the prototype of the mobile app prior to the intervention being implemented.
Key results: Altogether 95% of participants were diagnosed with a moderate intellectual disability and only 50% of participants managed to complete all the 6 social inclusion activities selected prior to the intervention being implemented. Examples of social inclusion activities included listening to music, swimming, shopping and taking a walk. The social interaction skills aligned with the selected social activity included a focus on listening skills, eye contact and communication skills. Staff uploaded 3 to 6 prompts as a step-by-step guide for each activity. The majority of participants reported the prompts as helpful in completing their social activities. Personalized pictorial images were uploaded on the mobile app for each activity and this encouraged and enabled participant interest. The majority of participants (96%) reported acceptance of the use and support of the mobile app when participating in social activities.
Conclusion: The mobile app was regarded as valued when used to help participants with improving their communication skills. More importantly, the significance of an intervention that used the support of a mobile app was seen as a unique facilitator to help communicate between staff and parents on how best to support young adults with ID at home and similarly at the day service. The findings of this pilot indicate that increased opportunities where participants can practice and participate in social interaction skills with the use of assistive technology are most needed. This will result in improving self-confidence and a sense of independence for young adults with ID when they engage in real-world social environments.
Keywords: Social Inclusion, Youth, Technology, Communication.
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Using High Fidelity Work Simulator for Vocational Orientation, Skill Assessment and Development of Young Adults with Disabilities

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Background: Work is crucially important for people with disabilities as it fosters their quality of life. Many studies focus on the assessment of vocational aptitude of people with different kinds of disabilities but most of them are qualitative research; paper based tests and simple observations. However, beside those technics our main focus is already on the accurately measurable functions that remained intact and therefore can be the basis of appropriate work skills. Hence, we used a sophisticated and complex high fidelity work simulator (WS) that has the necessary broad spectrum of evaluation test batteries. This research is a part of a complex vocational orientation program in Hungary for teenagers and young adults with disabilities. The main objective of our research was to create a methodology using a reference database to support aptitude assessment and work diagnostics of teenagers and young adults with disabilities to helping vocational school and career choices, labor market orientation or the assessment of specific job skills.
Referring to the well-known Human Activity Assistive Technology (HAAT) Modell – of which the occupational performance is an important element – it describes how a person performs an occupation. Assistive technology (AT) in a broader sense – includes any

assistive, adaptive, and rehabilitative devices for people with disabilities in order to promote greater independence by enabling them to perform tasks.

Method: The WS consists three measuring panels, as independent workstations. P1. for measuring static and dynamic forces in standing position, P2. for measuring holding/grasping forces, touching/tactile functions, and fine motor abilities in sitting position, P3. for measuring work endurance/loadability, monotony susceptibility in complex workflows. This full scale examination consists 36 different task situations each with 2–19 corresponding performance parameters, altogether totalling up to 203.

We compared the values of all these 203 measured parameters between the group of 179 "healthy" persons and the sample of the 100 "disabled" young (13–30 years) persons to determine which parameters are significantly different between these categories. We used mostly the One-Sample T-Test to compare each "disabled" sample mean with the corresponding "healthy" sample means as fixed numbers. A rather strict significance level of 0.01 was set instead of the usual 0.05.

Key results: We have found many statistically significant differences between groups. There are many remarkable overlaps of the "healthy" and "disabled" distributions: there were many "disabled" persons who performed better in certain parameters than the average of the "healthy" persons. Also there were many "healthy" persons whose performance was worse in certain parameters than the average of the "disabled" persons.

Based on the results of a work diagnostic measurements, we can give a feedback to students, career advisors or HR managers about the prospective employee's functional workability: which skills are outstanding, average, or need to be improved for the desired profession, career or job.

Conclusion: This broad variety of task situations and the vast repertory of corresponding measurable performance parameters of the WS makes it especially appropriate for skill assessment, skill development and also for vocational aptitude tests of different kinds of disabled persons.

Keywords: Work Simulator, Vocational Orientation, Skill Assessment,

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Technology and Disability 31 (2019) S165–S176
DOI 10.3233/TAD-190011
IOS Press

Part 8: Service Delivery and Outcome Research

Barriers to Assistive Technology in Europe

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Background: The results of the project "Barriers to the wider deployment of person centred technology in services for persons with disabilities," commissioned by the European Association of the Service Providers for People with Disabilities (EASPD) will be presented. The goal of the project was to identify what are the main barriers and consequently the potential facilitating factors that would enable the uptake of Person Centred Technology (PCT) in the social sector.
Method: The research work had two related parts – a theoretical analysis of the barriers to PCT based on existing studies; and the design and deployment of a questionnaire aimed at gathering data from professionals in service providers for People with Disabilities (PwD) as to their perception of the identified barriers. The theoretical part is based on some of the most important recent reviews and authoritative sources of information on the topic. Fifteen groups of barriers were identified. The questionnaire was developed following the theoretical analysis and it covers all identified groups of barriers. The questionnaire was administered in 5 languages and was filled in by 137 professionals working in social service providers for people with disabilities from 18 European countries. 100 participants were included in the subsequent analysis.
Key results: The results of the questionnaire show that professionals in Europe are unanimous about the usefulness of PCT for PwD (mean rating of 6.4 out of 7). However, the data about the percentage of service providers' staff members using PCT is alarmingly low – 36% overall (about 25% for Central, Eastern, and Southern Europe; 78% for Northern Europe). A similar large discrepancy between the North and the rest of Europe is also seen in the ratings about the good use of PCT in social service providers – 5.8 (out of 7) for the North and 4.5 for Central, 3.4 for Eastern, and 3.6 for Southern Europe. However, the average rating for Europe (4.2) is not satisfactory.
Another big issue is that only 22% of the service providers' staff is rated as being expert in PCT (50% for Northern Europe and about 12% for the rest of Europe). Additionally, according to the data, professionals working in SPPD have had on average less than 1 course in PCT during their formal education.
The analysis of the results shows that the most important barriers to the usage of PCT identified by the study belong to the following groups: Financial (except for Northern Europe with rating 4.5), Training, and Qualified Professionals barriers. Next in severity come the Resource, PwD and their Families' Knowledge and Skill, Environmental, and Legislative and Regulatory groups of barriers.
Conclusion: The results of the study show that despite some differences in perceived severity, the barriers to PCT in SPPD are common to Central, Eastern, Northern, and Southern Europe. The groups of barriers related to training and qualification with respect to PCT seem the most prominent for all Europe.
Facilitating measures need to be systemic, starting from the establishment of university curricula which will account for the exponential growth of PCT.
Keywords: barriers to assistive technology, professionals working with people with disabilities, training and qualification in assistive technology.
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Demanding Assistive Technology for Study and Work in Finland 2007–2018

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Background: Finnish legislation guarantees disabled people the right to assistive technology (AT) that improves their ability to manage their daily activities independently. Responsibility for providing and financing such equipment falls upon the municipalities. However, if an illness or impairment makes working or studying impossible without personal AT, the Social Insurance Institution of Finland (Kela) can acquire the needed devices. Kela provides only particularly demanding and expensive devices. This includes equipment such as video magnifiers, Braille and large-format displays and computers. Kela provides AT for people aged 16 or over. The aim of this study is to describe changes in the use of AT benefits paid by Kela in 2007–2018 in terms of different diagnostic and age groups and the cost of AT. In addition, the study describes reasons for rejecting AT applications.
Method: The study is based on Kela registers from 2007 to 2018 and a focus group interview for the five specialists responsible for the AT benefits at Kela.
Key results: The yearly number of disabled people who received AT acquired by Kela ranged between 550 and 600 persons in 2007–2018. Slightly over half of them were women. Most recipients belonged to the age group 16–19. However, the proportion of this age group in relation to the other age groups decreased yearly. Until 2012, most recipients were students, after which the majority were employed. The most common reasons for receiving the devices were related to vision loss and hearing loss. The number of devices acquired based on vision loss varied during the study period, whereas the number of devices acquired based on hearing loss increased. Other common conditions were neural diseases, such as cerebral palsy, but the number of acquired devices decreased over time. The total cost of the Kela-funded devices varied between 1.2 and 1.6 million euros, and individual AT solutionscost 2,000–2,500 euros on average. Kela rejected approximately one third [216–279] of the AT applications annually. The most common reasons for rejection were: the applicant did not have a sufficient disability, the device was not necessary for work or study, or the device was not demanding and expensive and needed to be financed by the applicant's municipality.
Conclusion: The yearly need for demanding and expensive AT acquired by Kela remains roughly the same. The number of recipients who are young or who study decreases over time. This may be explained by the fact that computer technology is now everyday technology and it is provided by schools or municipalities or bought by the persons themselves.
Keywords: Assistive technology, Provision, Study and Work.
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Augmentative and Alternative Communication Systems for Multilingual Contexts: A South African Perspective

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Background: In the field of augmentative and alternative communication (AAC) there is a dearth of knowledge to guide the design and implementation of AAC systems that give access to multiple spoken languages. With 11 official languages, South Africa is a context of linguistic and cultural diversity. However, due to a variety of socio-political and historical factors, AAC intervention and AAC technology are provided almost exclusively in English. Studies were therefore undertaken with the overall aim of developing augmentative and alternative communication (AAC) systems that would give access to expression in various South African languages. The aims of these studies were:

- To describe the perceptions and needs of stakeholders (rehabilitation professionals and persons using AAC) regarding non-English and multilingual AAC systems;
- To identify core vocabularies in three South African languages to guide vocabulary selection for non-English and multilingual AAC systems.

Method: The first study used a qualitative design. Online and face-to face focus groups were held with 15 purposively selected South African rehabilitation professionals working in the field of AAC to understand their perceptions of multilingual issues in AAC service provision including AAC systems and technology. Focus group data were analyzed using inductive thematic analysis.
In the second study, a predominantly quantitative survey design was used to obtain the perspectives of 27 multilingual South African adults using AAC on multilingual AAC issues. Participants were recruited through an empowerment program for adults using AAC and also through an email list. Data were analyzed using predominantly descriptive statistics.
The three core vocabulary studies made use of quantitative descriptive observational designs. Speech samples were collected from six isiZulu-speaking, six Sepedi-speaking and 12 Afrikaans-speaking preschoolers via body-worn audio recorders during routine preschool activities. Participants were selected using convenience sampling. The speech samples were transcribed and the linguistic units (words or morphemes, as dictated by the linguistic structure of the language) that were used with a frequency of at least 0.5‰and by at least half of the participants were identified as the core vocabulary.
Key results: Both stakeholder studies indicated a need for AAC systems that allowed access to South African languages and also access to more than one language. Desired technology features included text-to-speech capabilities, text prediction and pre-stored vocabulary in appropriate South African languages, and the ability to code-switch seamlessly. Core vocabulary lists were identified comprising of linguistic units (words and/or morphemes) used most frequently and commonly by preschoolers, ranging from 239 words in Afrikaans, 226 words in Sepedi, to 213 morphemes or formatives in isiZulu. The influence of linguistic structure on AAC system design was also highlighted.
Conclusion: The results highlight the need for and desired features of AAC systems that give access to non-English South African languages and also multilingual systems. Core vocabulary lists in the three languages can be used to assist with selecting vocabulary that allows for sentence construction and a level of linguistic generativity. These studies also highlight language-specific and language independent design considerations for AAC systems giving access to multiple languages.

Keywords: Augmentative and alternative communication, Core vocabulary, Multilingual, South Africa, Stakeholder, System design.
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Access to Appropriate Assistive Technology in Less-resourced Settings: Argentina's Case
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Background: Assistive Technology (AT) promotes inclusion in people with disabilities across their lifespan. Although AT products are essential, successful access depends on integrated efforts related to end users ('people'), provision, personnel, and policy, considered the 5 'P's by the (WHO- GATE). Argentina, is an emerging-frontier country, Currently, 32% of its population live in poverty and disability is prevalent in 10.2% of the population. Most remote and vulnerable places lack appropriate processes to guarantee the rights of people with disabilities. The existing way of wheelchair distribution is massive and disconnected from the essential Service. Challenges are lack of: person-center approach – policy implementation – services related to appropriate AT provision- maintenance of products. The aim of the pilot project research is to figure out if we can improve the results in inclusion with wheelchair provision service as a process in accordance to the WHO's paradigm.
Method: A Pilot project of AT provision was setup in Chaco Salteño, a vulnerable region of Argentina. A team of 3 experts composed by 1 physical therapist and 2 social workers defined the 7 phases for an adapted program on AT provision to ensure insertion of the WHO paradigm on the 5 "p" and the WHO's 8 steps of wheelchair provision. 7 Phases we planned in order to achieve our goals: 1: Advocating Policy/Provision, involve local government. 2: Personnel, community-based rehabilitation training. 3: People, referral people in need of AT. 4: Personnel, training 2 local leaders in product preparation. 5: Provision, assessment and selection by expert. 6: Product, funding, donations were accepted. 7: Provision/Personnel, follow up every 3/6 months. Interview to obtain results.
Key results:

- Coordinated efforts with the government to advance 5 "P" understanding the population's needs
- 32 users were provided with appropriate wheelchair and training

- 140 health agents trained in CBR increasing awareness shown in number of cases
- 2 local leaders instructed in product maintenance. Diminish abandon products
- Increased community participation / inclusion(fig.1)

Conclusion: This Program is just a pathway ensuring appropriate AT products and service provision for the vulnerable community. The benefits of AT should be known by the stakeholders involved with disabled people throughout their lifespan. Future perspectives:

- Monitoring and evaluation programs in order to build the evidence of the cost and benefits of AT.
- Building capacity goes hand in hand with the integration of these services into existing healthcare and social programs for ensuring equitable access to appropriate AT
- Program can be replicate in less resource settings in Latin America.

Keywords: Less-resourced settings, Service steps, wheelchair provision

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Availability and Awareness of Assistive Products in Bangladesh from the Perspective of Rehabilitation Professionals

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Background: Bangladesh is considered as lower-middle income country with approximately 164 million population. Although 9.1% of total population are experiencing disability, the production and distribution of assistive products (AP) have not been sufficient so far. Offering APs in the market and making appropriate choice to effective use of APs are two burning problems of Bangladesh. Affordable domestic production and imports from overseas may minimize demand problem but adequate knowledge of rehabilitation professionals (RP) about APs is indispensable for maximizing services. To improve this situation, this research was carried out first to reveal the kind of available APs in Bangladesh along with measuring the level of awareness of RPs about APs.

Method: As there is no any business enterprise to produce APs in Bangladesh, Center for the Rehabilitation of the Paralysed (CRP), the only rehabilitation center and Center for the Development of the Disabled (CDD), the prominent disability related organization play vital role in production and distribution of APs. On the other hand, WHO has developed a 50 Priority Assistive Products List (APL) to improve access to high quality, affordable APs for all in 2016. In this research, that APL was selected as a list of standard APs. The kind of available APs in Bangladesh, has been surveyed by analyzing statistical data published by CRP and CDD. To measure the level of awareness of RPs about APs, all the RPs of CRP were surveyed by questionnaire. The total participants were 115 RPs which included PT-52, OT-32, SLT-16, and P&O-15. In the questionnaire participants were asked about their awareness of 50 APs from APL along with their professional information. This research has been carried out from September 2018 to April 2019 with the permission of CRP Research Ethics Review Committee.

Key results: The survey result revealed that, 23 out of 50 kinds of APs from the APL were available in Bangladesh and all those available APs were from Mobility, Communication and Environment categories of APL. In terms of awareness of RPs about APs, only 1 participant from P&O knew all 50 APs from APL properly. However, there were 7 more participants (OT-3, SLT-3 and P&O-1) who knew 40+ APs from APL. The study also indicated that only 9 participants knew all the 23 APs available in Bangladesh. Statistical analysis indicated that the awareness about APs in OT was significantly higher than that in PT. The survey further denoted that 90.5% of RPs didn't have any knowledge about database of APs although 48.0% RPs obtained information of latest APs from internet. The study also found that 81.0% RPs never had an opportunity to participate any AP related seminar/conference outside Bangladesh and 13.1% RPs didn't have any scope to get information about latest APs.

Conclusion: The preliminary result of our research indicated that, the numbers of available APs in Bangladesh were fewer than the APL and the awareness level of RPs about APs was inadequate. Establishment of worthy environment to learn more APs effectively is highly needed along with solving the priority issues.

Keywords: Rehabilitation professional, Bangladesh, Assistive Products List.

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Assistive Technology Access: A global concern in the Canadian context – stakeholder perspectives on unmet needs, gaps in services, and ethical, social, and policy issues

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Background: As technology development advances, access to assistive technology (AT) remains a global concern. The World Health Organization has determined an urgent need for AT policies that enable equitable access nationally and regionally. In Canada, there are unmet needs and access to AT remains challenging, raising equity concerns. Programs offering AT are fragmented and complex, resulting in barriers for consumers and healthcare providers. There is a clear urgency for coordinated research and policy implementation for AT access. This study is part of a larger project to understand and advance Canadian policies for AT access. This study covers a previous gap in research by engaging stakeholder perspectives about AT in Canada in relation to policy, provision, and services. The purpose of the study is 1) to examine how AT is accessed by Canadians and identify funding/service gaps, and 2) to explore the perceived ethical, social, and policy issues affecting AT access and adoption. The findings will contribute to better aligning policies/services with the perceived social and ethical values of Canadians and improve equitable access through policy implementation.
Method: In this study we undertook 30 key informant interviews with Canadian policymakers and stakeholders representing federal, provincial, and territorial jurisdictions, and organizations operating nationally. Using a purposive expert sampling framework, the researchers aimed for 2–3 representative policymakers/stakeholders from 14 Canadian jurisdictions. Using thematic analysis, the researchers reviewed and coded interview transcripts, refining themes based on ongoing review and discussion. Themes were sorted based on value placed by respondents, frequency of appearance, and significance to the research purpose.
Key results: Three prominent needs emerged from the interviews, raising key issues to address in future policy proposals: 1) The need for a more holistic approach, offering a national-scale intervention to currently silo-ed services that limit AT access and do not reflect a client's full range of needs; 2) The need for client-centred policies and programs, offering broader inclusion and prioritizing choice and independence; 3) The need for capacity building, including education/awareness campaigns, and training for practitioners, clients, and caregivers – including those facing barriers to information, such as rural populations and newcomers to Canada. Under these themes, multiple gaps in service/provision/policy were identified, and a list of groups with unmet needs was developed. Respondents also identified proposals to address these concerns, including building national standards, providing subsidies, and developing centres of excellence for education.
Conclusion: The findings show what stakeholders and policymakers perceive as the greatest concerns for access to AT in Canada, highlighting the barriers and gaps in accessibility, as well as offering strategies for policy implementation and service improvement. The study offers practical implications to guide ongoing research engagement with policymakers and stakeholders. While based in a Canadian context, the study addresses a global concern and offers a meaningful contribution to the AT field by engaging in a process to improve access to AT. This work contributes to broader social change by addressing the call for accessible ATs to operate as mediators of sustainable and equitable development internationally.
Keywords: Policy, Access, Equity, Client-centred, Capacity-building

Continuous Outcome Scaling: A Discriminative Method for Person-Centered Assistive Technology Outcomes Studies

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Background: Accurate measurement is a critical element of assistive technology (AT) provision. Outcome measures which are useful in both clinical settings and field studies must have evidence which confirms their reliability and validity. This paper considers the appropriateness of using a graded visual analogue scale with grades as anchors for the scale. Specifically, the abil-

ity of graded visual analogue scales to discern meaningful differences for a population of young manual wheelchair users and their practitioners within low- and middle-income countries.
Method: This paper reviews the literature on continuous scaling applicable to assistive technology outcomes. We then describe the development of graded visual analogue scales using grades as anchors within a mixed methods protocol. Studies drawing on eleven datasets related to wheelchair and prosthetic/orthotic functioning are reviewed to identify important parameters for validation and to critically evaluate tool performance.
Key results: Graded visual analogue scales with grades are anchors demonstrate strong ability to discern meaningful difference. This method provides data with enough detail to make it useful usable for clinical and design responses.
Conclusion: Meaningful outcomes measurement with useable tools is critical to evaluate and build assistive technology access globally, and a high priority considering the UN Sustainable Development Goals. This paper proposes a protocol for use of graded visual analogue scales and demonstrates evidence of its reliability and validity across a range of studies. The graded visual analogue scale approach to outcome measurement offers relevant, rapid and sensitive measures, widely applicable. The paper concludes with considerations for the potential use of continuous scaling from the twin perspectives of consumer usability and utility in low- and middle-income countries.
Keywords: outcomes, disabilities, person-centered, continuous
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Towards a Successful Match Between User and Assistive Technology: A Correlational Study on User's Satisfaction, Perceived Effectiveness, and Psychosocial Impact of an Assistive Solution

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Background: This work is an exploratory study to investigate the relation among three main psychosocial factors measured after an Assistive Technology (AT) system provision: (i) the user's satisfaction, (ii) the perceived effectiveness, and (iii) the psychosocial impact of the assistive solution. The main objective is to understand whether the correlated psychosocial measures can predict a successful outcome of the AT assignation process. The study embraces the ICF's biopsychosocial perspective of disability and the Matching Persons and Technology model by adopting the Assistive Technology Assessment (ATA) process, an ideal model for the effective outcome of AT assessing and provision (Federici & Scherer, 2018).
Method: The study was conducted in an AT service delivery center by following the guidelines provided by the ATA model. Fifty-five subjects (72.7% males, min 4 – max 14 years old) participated in the study, which consisted of five main phases. Two preliminary phases focused on the analysis of participants needs with the aim to identify the best AT solution through a psychological counseling process and the administration of the Matching Assistive Technology & Child (MATCH; Federici et al., 2009). Then, the third phase of post-assignation focused on the outcome of the assistive solution assignation process measuring the user's satisfaction and the perceived effectiveness, as well as the functional independence, well-being, and quality of life. The factors were assessed through (i) the Quebec User Evaluation of Satisfaction with assistive Technology (QUEST; Demers et al., 2002), (ii) the Individually Prioritized Problem Assessment (IPPA; Wessels et al., 2002), and (iii) the Psychosocial Impact of Assistive Devices Scale (PIADS; Jutai and Day, 2002). A final post-assessment phase consisted in providing the users with tailored training for the use of the assigned AT and in conducting interviews to caregivers (teachers and educators) and peers to investigate the impact of the AT solution in the users' milieu.
Key results: Findings after the AT system provision showed high levels of user's satisfaction (Total QUEST $M = 4.80$; QUEST device $M = 4.71$; QUEST services $M = 4.99$), an increase in quality of life levels and a decrease of about 40% of the perceived difficulty of use. A highly significant positive correlation among the three questionnaires QUEST, IPPA, and PIADS was found ($0.473 \leqslant r \leqslant 0.762$; $p \leqslant 0.01$). A significant linear relationship between the questionnaire scores and the abandonment rate shows that questionnaire scores can predict each other ($0.224 \leqslant R^2 \leqslant 0.581$; $p \leqslant 0.01$). Finally, the AT assessment outcome showed a 5.17% rate of abandonment.

Conclusion: A positive relation among psychosocial factors of users' satisfaction, perceived effectiveness, and the psychosocial impact of the assistive solution highlighted a statistical dependence among the three different metrics recommended by the ATA model for the post-assignation assessment process (QUEST, IPPA, and PIADS), also explaining the strength of each psychosocial factor on the AT assessment outcome in terms of abandonment of the assistive device. Future works will extend the age range and focus on designing a mathematical model for predicting the percent probability of AT getting abandoned by the user, immediately after the post-assignation assessment process.

Keywords: Assistive Technology Assessment model, Matching Assistive Technology & Child – MATCH, QUEST, IPPA.

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What is the pay-off? Usability and cost benefit of assistive technology at workplace

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Background: Assistive Technology (AT) devices enable individuals with disabilities (IWDs) to fulfill work roles and engage in meaningful employment. However, the employment rate of IWDs in the United States is significantly lower (18.7%) compared to that of able-bodied individuals (65%). A major factor here pertains to barriers with implementation of AT devices. To highlight the role of AT, we conducted a comprehensive survey of employees with disabilities on their use and utilization of workplace AT. Specifically, the study sought to: a) identify AT devices that are being used at work; b) examine how well the devices effectively and efficiently fulfilled work roles; c) examine perceived skills and accommodations for use of AT; and above all; d) analyze the cost-benefit of integrating AT devices at workplace.

Method used: The survey was developed using a pilot-tested work-driven framework, the Usability Scale for Assistive Technology-Workplace (USAT-W). The framework first delineates the work roles of the employee, focuses on tasks within each role, and then considers the AT support needed to fulfill each role. The effectiveness and efficiency with which the employee interacts with the AT devices, as well as the skills involved and accommodations received for each device within the roles, are then evaluated. This framework was adapted into the survey, pilot tested with a small cohort of employees with disabilities, and then uploaded on Qualtrics survey database. We included an additional section seeking information on the employee's income and total cost with acquisition, training, and service for each AT device. Convenience sampling was used to recruit participants across the United States from multiple sources- Qualtrics health panels, disability support networks, and Centers for Independent Living.

Key Results: 206 employees with disabilities who used AT (with an average 8.1 years of work experience) completed the survey. The three main categories of AT were worksite modifications (25.7%), devices for mobility (23.8%) and computer access devices (21.8%). Nearly 90% of respondents rated themselves to be "productive" to "very productive" in all work roles involving AT. About 84% to 93% stated their AT devices to be "effective" or "very effective", and "efficient" or "very efficient" for fulfilling their work roles. Significant correlations (r ranging from 0.3 to 0.6; $p < 0.01$) were detected between AT skills, accommodations, and work productivity. In contrast to the average annual income of \$47,135 (Std.dev = \$33,558), the average total cost of AT devices was \$7074 (Std.dev = \$15,868), almost a 7:1 ratio. Despite the high variance, the one-time total cost of AT devices was a much smaller fraction of the respondents' annual income across all impairments and job categories.

Conclusion: These findings indicate the breadth and role of AT devices at work. The economic benefits of providing AT with respect to income and earning potential far surpass any associated implementation costs. While past research has delineated barriers to AT provision, underscoring the value and economic pay-off of workplace AT is critical to highlight the role of AT to service providers, employers, and policy makers.

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Technology's Impact on Tasks of Employees with Disabilities in Germany (2006–2017)

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Background: The ongoing computerization of our economy leads to a transformation of the world of

work. New technologies and new working requirements result in changes in employees' task composition. According to the Routinization hypothesis, the increasing use of computer technologies in the workplace is leading to a complementary of non-routine (analytic and interactive) tasks and substitution of routine (manual and cognitive) tasks). This paper analyses the influence of the computerization (the use of computer as main work tool) on the tasks of employees with disabilities. It is examined whether the technological change is leading to the same shift towards more non-routine tasks and to the same substitution and complementary effects of technology in workplace among employees with disabilities as it is among those without impairments between 2006 and 2017.

Method: We use representative data form the German BIBB/BAuA Employment Surveys 2006 and 2017, where 20,000 gainfully employed people were asked about their Qualification and Working Conditions. We run separate regression models for employees with and without a certified disability in the years 2006 and 2017, where we analyse the influence of computer usage (independent variables) on different task categories (routine, manual, interactive and analytical tasks; dependent variables).

Key results: Our results show no significant differences in the technology usage of employees with and without disabilities on workplace. Moreover, the impact of technologies on the tasks carried out do not differ significantly between disabled and non-disabled employees.

Conclusion: The analyses confirm the Routinization hypotheses for disabled employees: the usage of technology on workplace is leading to the same shift towards more non-routine tasks and to the same substitution and complementary effects on tasks for disabled and non-disabled employees. One explanation for the fact that computerization affects in the same way people with and without disabilities could be that the data used focusses on persons who are integrated in the general labour market. In future research we will analyse the effect of various types of technology (e.g. tools for communication and information management, input and output devices for computers) on the tasks of employees with different impairments to find more differentiated results.

Keywords: Disability, Labour market participation, Routinization.

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Assistive Technology Outcome Measures: A Review of Recent Literature

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Background: Effects, costs and economic impact of assistive technology are indicated among the top priorities in the Global Priority Research Agenda on Assistive Technology, published by the World Health Organization in 2017. Internationally validated AT outcome measures can be useful to measure whether AT interventions lead to successful outcomes at individual level, and more in general to collect evidence about AT appropriateness and cost-effectiveness. The authors – who work in AT assessment teams of rehabilitation and AT centers – were interested in finding out outcome measures applicable to any AT categories, which could be used in the follow-up stage of AT interventions in daily practice.

Method: A literature overview was undertaken in order to identify validated outcome measurement tools, in use among the AT communities, that could be applied to any individual AT intervention. Three AT experts identified a list of 13 journals and 3 conference proceedings whose field of interest included AT, and analyzed articles published in their 1312 releases between 2003 and 2016. First, 459 articles were retrieved that contain the terms "OUTCOME" or "MEASURE" or "EFFECTS" or "TOOL". Second, each expert read the abstracts and assigned a relevance score. Papers were considered "relevant" if the abstract declared that the described instruments were intended to measure the outcome of individual AT interventions; otherwise they were scored as "not relevant". Third, the 53 articles scored as "relevant" by all the three experts were analyzed in depth and the data describing the study and the instruments were extracted and coded. For example, each instrument was classified according to whether it was: 1) intended for general use in rehabilitation programs, 2) designed to be applied to specific categories of assistive products, and 3) applicable to any AT products.

Key results: 86 instruments were reported in the 53 selected articles. However, only 5 instruments were found to be outcome measures actually applicable to a broad range of assistive products: *PIADS*, *QUEST 2.0*, *FIATS*, *IPPA* and *SCAI*. These instruments were described in 29 articles, which indicates they are

quite widely known and used in several Countries. These instruments investigate different outcome domains – respectively – *psychosocial impact*, *satisfaction*, *caregivers' burden*, *perceived effectiveness* and *social costs*.

Conclusion: Outcome measures are extremely important to demonstrate the AT fundamental role and added value, to quantify their impact and to inform funding decisions. However, a very simple set of easy-to-administer measures should be chosen to make the measurement sustainable in clinical practice. The five instruments identified by this study seem to meet this need; they also investigate different outcome domains whose combination provides a comprehensive insight into the AT impact on the user's life. The authors are currently engaged in further research to seek the best compromise between making outcome measurement sustainable in clinical practice and collecting the whole spectrum of data that can fully enlighten the AT impact.

Keywords: assistive technology intervention; outcome measurement; follow-up

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Outcome of Provision of "Uncomplicated" Assistive Devices to Older People in the Faroe Islands – an IPPA pretest-posttest Study

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Background: Researching the outcomes of assistive devices (ADs) is important for clinical and policy decision-making. The Faroe Islands have an ageing population, and there is a lack of knowledge about outcome of ADs for older people. Older people recieve most of the ADs from the publicly funded AD-centre. This study aimed to evaluate to what extent older people experience diminished difficulty in performing daily activities due to provision of uncomplicated ADs, e.g bath chairs and rollators. Additionally, the aim was to examine possible association between effect and "sociodemographic factors" and "difficulty at baseline". This is the first study of AD provision in the Faroe Islands.

Method: The design was a pretest-posttest AD intervention study. It was conducted in five out of seven municipal districts and ran for eight months. Seven municipal OTs collected data in their districts. Inclusion criteria: citizens 67 years and older living at home who wished ADs to perform daily activities. Exclusion criteria: citizens without sufficient cognitive or hearing functioning necessary to participate in an interview and citizens with massive need for care. Data collection: The effect was evaluated by means of the Individually Prioritised Problem Assessment (IPPA). IPPA assesses to which extent activity problems identified by AD users are diminished after recieving ADs. At baseline, the participant identified and rated their activity problems regarding importance and difficulty and re-evaluated them at follow-up 3.5 months after receiving the ADs. The scores range is 1–25 points. A high score demonstrates a large difficulty. The effect is the difference between mean baseline score and mean follow-up score. Max possible difference is 24 points, which demonstrates a large effect. Intervention: municipal OTs assisted with the application for the ADs from the state AD-centre, that might address the activity problems. When the ADs were recieved, the OT paid one visit to test and adjust the ADs, and to instruct in using. The overall effect was assessed with a paired t-test. The effect size was calculated and interpreted according to Cohen's d: an effect size of 0.20 is small, 0.50 is moderate and 0.80 or more is large. One-way ANOVA was used to explore association between the effect and the determinants.

Key results: In total 52 persons, 37 women and 15 men aged 69-93, mean age 83 years participated in the study.

Mean baseline total score was 17.73 (SD $=$ 4.09), mean follow-up score was 9.14 (SD $=$ 3.41). Mean reduction in difficulty was 8.59 points (95% CI: 7.37–9.81) ($p \leqslant 0.001$). At the individual level the effect was -5–20 points. Effect size was 1.96. Only "high difficulty at baseline" was associated with large effect ($p < 0.001$).

Conclusion: The effect size by 1.96 was large and shows positive effect of the AD provision. Only difficulty at baseline was associated with large effect. The variation of effect highlights the importance of evaluating AD interventions on an individual level. Further studies are needed to investigate which factors in the service delivery proces influence the outcome. This could provide the authorities with evidence in the planned re-evaluation of the AD service.

Keywords: assistive devices, outcome, older people, daily activities.

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Developing an administration manual for the electronic Mobile shower commode ASsessment Tool (eMAST): A case study

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Background: In Assistive Technology (AT), there is an ongoing need to develop, implement, and report on outcomes of AT provision and service delivery. In the past decade, efforts have largely focused on developing and validating new outcomes measurement instruments for use in real-world service delivery settings. In order to utilize these in practice, experts in instrument development recommend that documentation, in the form of administration guides or user manuals, should also be produced. While many resources exist to support instrument development, comparatively few appear available for developing administration or user manuals. Such documents serve as a single, comprehensive repository of information on an instrument to facilitate their uptake and use in practice. The purpose of this paper is to describe the development of an administration manual to accompany a recently-developed outcomes measure, the electronic Mobile shower commode ASsessment Tool version 1.1 (eMAST 1.1). The eMAST, first published in 2016, assesses mobile shower commode usability from the perspective of adults with spinal cord injury. This paper serves as a practical case study on developing an administration and user manual for researchers undertaking such work.
Method: The author reviewed the following resources to identify necessary elements for an administration manual: published literature on scale development; published guidelines from online repositories and distribution platforms on administration manuals for instruments hosted on their sites; data extraction domains used in published reviews of AT outcomes measures; and published administration or user manuals for existing, validated outcomes measures for wheeled mobility and usability.
Key results: The following elements were identified as necessary for inclusion in the eMAST administration manual: administrative details of the instrument including its full name, authors and their contact details, copyright status, authorized distributors, requirements for training or accreditation of administrators prior to use, costs or fees for licensing and use, reporting and disclosure requirements, and recommendations for citations in publications; background information on the development and validation history of the instrument, including a summary of key development phases, populations used for validation, and potential limitations or threats to validity; psychometric properties as reported in published studies; administrative properties as reported in published studies; instructions for use and guidance on administering the instrument, including recommended delivery format/s and availability of templates or formatted instruments (i.e. electronic, online, paper), recommended timing for administration (e.g. immediately after using the AT or after a week of use), scoring of the instrument, and interpretation of sub- and total- scores. These elements were then used by the author to create a draft version of the eMAST Administration Manual. The draft will be subject to external review by potential administrators of the eMAST in both research and service delivery settings.
Conclusion: This case study describes development of an administration manual to accompany a validated outcomes measurement instrument. The comprehensive manual contains information on the instrument's background, psychometric and administrative properties, and administration procedures for the eMAST. The manual will next be subject to external review by experts.

Keywords: Outcome measures; Questionnaires; User administration manual; mobile shower commode chairs; Practitioner research.

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Cross-Walking the Matching Assistive Technology to Child Assessment to the ICF Model

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Background: The Matching Assistive Technology to Child-Augmentative Communication Evaluations Simplified (MATCH-ACES) assessment incorporates the International Classification of Functioning, Disability and Health (ICF) model within the assessment framework in order to provide a common language and structure for assistive technology assessments. The purpose of this descriptive analysis is to cross-walk

constructs of the MATCH-ACES assessment to the ICF in the areas of educational participation, academics, and functional living skills with a special emphasis on intellectual disabilities. The authors hypothesize that the MATCH-ACES constructs/questions will correlate with the ICF body & structures codes, activities and participation codes, environmental codes, and predisposition factors that influence assistive technology use.
Method: The lead author created a preliminary crosswalk and electronic database and cross-referenced the MATCH-ACES assessment questions (constructs) to the ICF domains using a typology mapping table and established criterion rules. The crosswalk was examined by two additional reviewers to determine the level of agreement of the MATCH-ACES constructs mapped to the ICF domains. Feedback was incorporated into the second revision of the crosswalk and the primary author developed a concept map visualizing the crosswalk of both assessments with a focus on intellectual disability.
Key results: Preliminary results indicated a high percentage of agreement between both reviewers in cross walking the MATCH-ACES assessment to the ICF model. Specific outcomes of this analysis include the development of common AT language across universal assessments in healthcare and education and the focus on participation for children and youth with impairments that impede function. This is the initial stage in mapping both assessments to develop a standard AT assessment with universal language for healthcare providers. Further research is needed to conduct a larger analysis of the constructs mapped to establish further reliability of this process.
Conclusion: A preliminary analysis found the MATCH-ACES assessment process cross-walks with the ICF model in both the cognitive components of the needs analysis form and the predisposition scales. A second contribution relates to the need to develop a standard assessment process that uses evidence-based research and universal terminology.
Keywords: Matching Assistive Technology to Child (MATCH), International Classification of Functioning, Disability and Health (ICF), Crosswalk
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Translation and Preliminary Validation of the Italian Version of the Family Impact of Assistive Technology Scale for Augmentative and Alternative Communication (FIATS-AAC.it)

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Background: Developing effective communication skills is crucial for social and cognitive development, everyday functioning and inclusion in society. Interventions to improve communication skills of children with communication-related disabilities make use of alternative and augmentative communication (AAC). Recent studies have shown the effectiveness of these interventions on a number of clinical conditions; less clear, however, is whether the benefits from AAC interventions extend also to children's families. Understanding the impact of AAC on the lives of children and their families is important because family members often play a fundamental role in the successful integration of an AAC system into child's life. The Family Impact of Assistive Technology Scale for Augmentative and Alternative Communication (FIATS-AAC) is an emerging, reliable parent-reported outcome measure designed to detect the functional impact of AAC interventions on family systems. The present contribution reports on development and evaluation of the measurement properties of an Italian version of the FIATS-AAC (hereafter, FIATS-AAC.it).
Method: The authors translated and adapted the FIATS-AAC to the Italian context by following a standard linguistic validation protocol that employed a translation-back-translation technique. The initial FIATS-AAC.it was administered by either phone or face-to-face encounters to 30 parents or caregivers of children with chronic disabilities who were aged 3 to 18 years. Parents completed the FIATS-AAC.it twice with a one-week interval. During the second administration, parents also completed the Impact on Family Scale (IFS) to assess construct validity. The IFS is a published measure of the psychosocial consequences of having a child with a disability on the family.
Key results: Test–retest reliability for the FIATS-AAC.it total scale was acceptable (intraclass correlation coefficient (ICC) = 0.98 (absolute agreement). Internal consistency for the total scale was also acceptable (Cronbach's alpha = 0.87). Individual alpha values for FIATS-AAC.it subscales ranged from 0.19 to 0.87, with 9 of 13 dimensions exceeding the reco-

mmended threshold for homogeneity (alpha $\geqslant 0.7$). As hypothesized, correlational analyses revealed a negative correlation between FIATS-AAC.it and IFS ($r = -0.73$; $p < 0.01$), suggesting that the measure taps into a construct related to the psychological consequences of having a child with a disability. However, parents and AAC professionals reported the 89-item FIATS-AAC.it to be lengthy (about 20 minutes to complete).
Conclusion: The FIATS-AAC.it is a promising Italian tool to assess the child and family functioning in areas that may be impacted by the introduction of AAC interventions. The present study provides support for the reliability and validity of the total scale. The measurement properties of the FIATS-AAC.it generally align with those reported for the original English version. Further research is needed to confirm these findings and other properties (responsiveness). In addition, a shorter version would be a welcomed alternative for both AAC professionals and parents.

Keywords: AAC, children with complex communication needs, outcome measurement, effectiveness, family-centered services.

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Technology and Disability 31 (2019) S177–S182
DOI 10.3233/TAD-190012
IOS Press

Part 9: Policy

International Classification of Functioning, Disability and Health and the Convention on the Rights of Persons with Disabilities as a Framework for AT Classification and Categorization

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Background: Assistive technology is a powerful enabler of the person's participation in the different environments. Assistive technology is however understood to be many things by many stakeholders and this limits its potential. Dominant medical and rehabilitative discourses have shaped assistive technology language, terminology, scope, research priorities and outcome measures. The rights-based model considers assistive technology as a human right, a need and an enabler of full participation in all aspects of life of the person. This paper considers this history, reconciles the AT approaches, and proposes a new model drawing on two powerful contemporary frameworks.
Method: The constructivists argues that knowledge can be generated through critical discourse analysis (CDA) and we reflect on early claims of knowledge manifested in academic and non-academic literature related to ways of codifying assistive technology. The research paper is also informed by the standpoints of the authors and AT user experience of the first author. A content analysis of three pivotal articles is conducted utilizing UN CRPD as an AT categorization framework model and WHO ICF model as a classification framework model. The authors critically analyse the difference between AT classification (classes with fixed boundaries) and AT categorization (categories with flexible boundaries) systems and their implications for framing assistive technology.
Key results: Existing studies on AT Classification systems do not take the UN CRPD into consideration or differentiate between AT solution classification and categorisation. The AT Functioning, classification and categorisation (ATFCC) model organizes AT solutions (AT products, services and users) into both classes and categories under a one framework model. AT Classification system is based on the WHO-ICF model (body functions, and compensation of the body structure functions), medical and social model approaches towards persons with disabilities. AT categorization is based on the human rights-based approach and the Functional Diversity model towards persons with disabilities. AT solution classes are outcome of the interaction of AT solution with the person's body parts with function limitations and body function limitations. AT solution categories are outcome of the interaction between AT solution and a person's environmental or participation context. This model enables holistic AT assessment because it captures both the body function or body structure function difficulties and the full participation context of a person with functional difficulties in need of AT. Such a model may facilitate equitable allocation of resources for diverse AT users and purposes.
Conclusion: This model enables holistic AT assessment because it captures both the body function or body structure function difficulties and the full participation context of a person with functional difficulties in need of AT at the same time. Such a model may facilitate equitable allocation of resources for diverse AT users and purposes. ATFCC framework model influences formation of AT information and data management system by organizing AT solutions in classes and sub-classes and categories and sub-categories based on the WHO-ICF and UNCRPD respectively. It can facilitate the development of AT policies and AT funding models to cover a wide range of AT needs to enable participation in all aspects of life.

Keywords: Functioning, Rights, Assistive Technology, Classification, Categorisation.

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Political factors and assistive technology: A Multiple Streams Framework analysis of assistive technology landscape

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Background: To maximize the promise and sustainability of the assisitive technology (AT), AT interventions need to be recognized in legislations and policies. However, this is not the case within the Canadian AT landscape, which creates a significant variation in the availability and accessibility of the AT interventions. These discrepancies lead to system-level barriers that prevent AT professionals from effectively supporting AT users. The aim of this paper is to:

1) understand political complexities impacting the Canadian AT landscape and the potential for AT policy advancement;
2) identify how AT professionals can support the AT policy advancement by considering political complexities.

Method: This paper draws on the Kingdon's Multiple Streams Framework (MSF) to identify actions and conditions necessary to place AT policy advancement on the government agenda to stimulate policy relevant changes to optimize the AT provision. The MSF is a political theory that examines how issues get onto the policy agenda and how proposals are translated into policy changes. Kingdon generates MSF's key theoretical constructs by outlining meaningful categories of policy formulation into three streams: problem recognition, generation of policy proposals and politics.

Key results: The current categorization of the AT provision under the healthcare umbrella prevents government actions towards optimization of the AT system. Currenly, the AT concerns are not perceived as pressing problem when compared to more easily understood medical priorities (e.g. shortage of hospital beds). To stimulate actions from the government, AT professionals must highligh a mismatch between the current AT situation and the government's conception of the optimal state. For example, repositioning AT concerns from the healthcare to a social justice issue that impacts one's ability to enjoy fundamental rights re-defines the current AT concerns as a problem appropriate for a prompt governmental action. For the policy to be enacted, AT professionals must generate policy proposals that are technically and politically feasable, grounded within the language and value system practiced by the policy makers. The AT professionals must recognize a long gestational process for the proposal to be considered a 'go-to' solution, thus, AT professionals must concentrate their efforts on preparing both policy and public communities to the proposed solutions. Currently, the Canadian national mood is not receptive of the AT policy advancement, thus AT professionals need to lay the groundwork for shaping the receptiveness of national mood to the AT policy reform by engaging with people in and around government. Once the policy window opens, it will allow AT professionals to 'push' proposed solutions by coupling them to the emergence of pressing problem and political events.

Conclusion: Within the current Canadian AT landscape, policy windows are tightly closed, as the inadequate AT system has not been defined as a problem and the national mood is not receptive to the AT reform. However, as policy windows are short-lived opportunities for change that require immediate and well-thoughtout actions, present environment is favourable for the AT professionals to initiate the AT policy advancement process with the clear understanding of the political factors influencing the AT landscape.

Keywords: AT, political realities, AT policy advancement.

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Re-thinking the Advancement of Assistive Technology Systems from the Human Rights Perspective

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Background: Despite a social advancement in the notion of disability and the identification of the assisitve technology (AT) as a human right by the United Nations Convention on the Rights of Persons with Disabilities (UNCRPD), the constructs of the medical model of disability still underlie many of today's

AT policies and practices. With the momentum created by the Global Cooperation on Assistive Technology's (GATE) call for user-central redevelopment of AT systems, an important question arises of how to address the structural discriminations rooted deep within the existing AT systems and re-frame these systems to reflect users' decision making over the resources that impact their lives. A possible answer lies in critically examining and re-framing the existing AT systems through a human rights perspective.

Method: This paper draws on the United Nation's Human Rights Based Approach (HRBA) to explore a paradigmatic framework shift necessary to advance AT systems to best serve its intended beneficiaries. The HRBA is a conceptual framework that seeks to understand and address the root causes of systemic problems by analyzing implicit inequalities and discriminations within the existing systems.

Key results: The application of the HRBA to AT, shifts the way AT and AT systems are conceptualized. A HRBA framework positions AT as a tool that responds to human diversity and fosters an inclusive society. It further conceptualizes AT system as a system that aims to maximize social inclusion and the exercise of equal rights through user-driven AT provision. Furthermore, the application of the HRBA to AT, redefines unequal power-relations and establishes new roles and relationships between:

1. people with disabilities (PwD) as rights holders and active members of society – who can make their own decisions and claim their rights to AT and
2. government bodies as duty-bearers - who are obligated to respond to PwD claims and fulfill their rights to AT.

Transformation of the power-relations illuminates discrimination and injustices within the current AT systems which stems from the outdated conceptualization of disability rooted deep within existing AT policies and practices.

Through the identification of systemic discrimination within the current AT system and through recognizing PwD as key actors in the decision making process that impacts their lives, the HRBA:

1. empowers PwD to challenge inequities within the current AT systems;
2. emphasizes the responsibility of the government bodies to respect, protect and fulfill the right of PwD to appropriate AT.

Conclusion: The HRBA brings forward a novel perspective to the AT field as it focuses on recognizing structural causes behind the inadequate AT systems and addresses these by transforming the unequal power-relations between PwD and government bodies, thus stimulating a fundamental change within AT systems. However, in order to translate HRBA efforts to meaningful actions, it requires a deep political knowledge of AT context, mapping of actors and alliances, and understanding dynamics of policies that prevent effective enjoyment of AT rights. The effectiveness of HRBA application to AT and its proposed potential requires collaboration with and 'buy-in' from those who currently have power.

Keywords: Human rights approach to AT.

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"Equipping, Empowering, enabling": Center-staging Assistive Technologies in Disability and Rehabilitation Policy Discourse in India

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Background: Global demographic and epidemiological transition reflects an upsurge in NCDs, ageing and injuries with manifold rise in disabilities and functional impairment. World Health Assembly Resolution (2018) called for greater emphasis on Assistive Technology (AT) including strengthened data, policy, standards and investments. South-East Asia (SEAR) has the second highest prevalence rate of moderate disability (16%) and third highest prevalence rate of severe disability (12.9%), as per the World Disability Report (2011). The 2011 Indian census recorded 2.21% of the total population (26.8 million persons) as Persons with Disabilities (PwDs). WHO estimates indicate 90% of the PwDs have no access to ATs; the inability to afford and maintain ATs result in exclusion, poverty and increasing burden on affected families/communities, especially in low and middle income countries.

This review is a critical analysis of the evolution of contemporary global mandates and priority areas in AT

research; and, how the Indian Council of Medical Research (ICMR) plans to align Indian research and programmatic priorities along the global dialogue.
Method: Policy review and analysis was undertaken by a three member inter-disciplinary team of public health experts, selected by the ICMR's Disability and Rehabilitation Unit. Key international and national documents of the last ten years including policy documents, reports, WHO technical papers, academic articles and advocacy pieces were reviewed and triangulated.
Key results: The results have been divided in two sub sections

A) *Emerging priorities articulated across global and national agenda which need to be addressed by policy decisions and revised research strategies* – A review of global and national type and quality of data on estimates of unmet need found it to being complete and fragmented. To bridge the gap in policy and practice a comprehensive national policy for people with disabilities and functional impairments was identified to strategically channelize available resources. Program priorities for ATs ought to address both service provisioning as well as research; and to establish linkages across primary, secondary and tertiary levels of care.
B) *India specific initiatives undertaken by ICMR* Disabilities or functional impairments need to be treated/managed as distinct epidemiological entities, for which ATs constitute the core intervention (for rehabilitation). The AT industry as well as the policies regarding its design, manufacturing, marketing and provisioning is evolving in India. The WHO recommends a distinct program for ATs that needs to take account of demand, manufacturing, standards, availability, affordability, reach, maintenance and sustainable use. The ICMR plans to align its research priorities as per the international conventions and WHO recommendations; national priority areas for research were also identified.

Conclusion: Research for ATs needs to take into account demand, manufacturing, standards, affordability, reach, maintenance, and sustainability. Public health care systems and sub-systems requires comprehensive package for disabilities and functional impairments attributed to ageing, NCDs, mental health disorders and injuries along with prioritizing cost-effective approaches in LMICs. Strategy should not be just about availability of devices or technologies but comprehending the complex lived experience of the PWDs across age, socio-economic groups and shaping a flexible and sustainable system that is equitous to this vastly disadvantaged group.
Keywords: Assistive Technology, India, Policy, LMICs.
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Access to Assistive Technology in Hungary – What is (Not) Done About it?

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Background: There are almost 500.000 people who consider themselves disabled in Hungary. There is no available statistical data regarding the number of people in need for an assistive device, although 1.5 million people, 15% of the whole population face difficulties in everyday-life activities based on the latest (2016) available representative, self-reported data. The number of people in need for an assistive device is increasing as the population ages and most of them are in need of financial support to access: families which include at least one person with disabilities earn 15 percent less in average than a family without a disabled member and the risk of social exclusion and poverty is 22 percent higher among people with disabilities than in the non-disabled population. What kind of assistive devices and related services does the Hungarian state provide, for whom, under what eligibility conditions and why? The presentation will conclude the partial results of a doctoral research (2017–2020) which will examine the role of the state in assistive technology provision in Hungary compared to 4 other European countries (IT, DE, DK, UK).
Method: The PhD research focuses on the role of the state in Hungary, the examined variables are legislation, financing, provision and control concerning AT accessibility. The methods used for the presented Hungarian study are qualitative: besides the literature review, comprehensive legislation analysis, sociological professional interviews and user interviews were made. The thesis will include sociological illustrative case studies about Italy, Germany, Denmark and the United Kingdom which can demonstrate good practices or, in any event, different patterns of accessibility. With the exception of Hungary, the case studies are built upon ongoing short study trips to the founding member institutions of the European Assistive Technology Information Network.

Key results: It was found that there are large inequalities between Hungarian people who can afford a product themselves and the ones who need financial support to do so. One of the most important human rights is flouted depending on the financial status of the user: freedom of choice. There is a national list of medical aids, those can be granted through social insurance, but the list has not been updated for ages meaning the ISO 9999:2003 is used. The provision system is obsolete and there appears to be a considerable obstacle to modernize it: the financial-economic aspects appear to have precedence in policy-making over professional and user-orientated considerations. The greatest losers of the obsolete system are people with communication disorders and severe disabilities as well as people with mental health conditions and children.

Conclusion: The presented section of the PhD research is the first analysis of the Hungarian AT provision on the field of social policy that creates the possibility of international comparisons. The study points out significant inequalities in accessibility which can contribute to forming the main indicators of the national policy-making.

Keywords: assistive technology, accessibility, social policy, service delivery, Hungary.

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Young women, Disability and Technology: A Survey Study from the RISEWISE Project

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Background: The "RISEWISE"-project (Horizon 2020, GA690874) investigates barriers that women with disabilities meet in their life. Technology can either be an enabler or a barrier for them. Within the project a survey was carried out to investigate the relationship between technology and disability and to compare the perceptions of young women with (WD) and without disabilities (WW).

Method used: The survey, targeting women belonging to the digital generation (age between 15 and 29 years old), was developed in English and translated in three languages (Italian, Spanish, Turkish) to obtain a cross cultural data set. The survey consists of 234 items in different sections: autonomy, frequency of technology use, satisfaction with technology, software, apps and social media preferences, confidence in using smartphones, interaction with technology, benefits and impact of using technology, barriers for technology use, support needs and perceptions regarding gender differences in technology use. The survey was administered to the participants online. Non-random, snowball sampling was used in data collection between September 2018 and March 2019.

Key results: Preliminary results arise from 228 women that have completed the survey, of which 27 by WD's: (motor (6), visual (14), hearing (2), emotional-relational (1) and multiple (4)). Bivariate correlations among variables showed that for the entire group there is a significant positive relationship between frequency of technology use and level of satisfaction ($r = 0.83$, $p < 0.01$), expected benefits ($r = 0.31$, $p < 0.01$) and empowerment ($r = 0.28$, $p < 0.01$). As the perceived benefits of using technology increase, there is a significant increase in empowerment ($r = 0.80$, $p < 0.01$), in needs and wishes regarding technology ($r = 0.41$, $p < 0.01$) and in support needs ($r = 0.44$, $p < 0.01$). No significant differences were found between WD and WW, except in the main areas of felt empowerment: both indicated "education" and "information gathering", while WD highlighted also "employment" and WW "communication". Further, WD indicated "to find more appropriate solutions for my needs", "to have better skill in using technology" and "to have more information about the options" to be strongly related to their needs regarding technology. The barriers that prevent technology use are different for the two groups. WD mentioned the lack of support from public institutions, accessibility issues and lack of information and support while WW mentioned lack of time, money and interest. WD expected support mostly from paid experts, AT centers and producers/companies. Both groups agree that gender differences between men and women impact on the purpose of using technology, the choice and the intensity of use. For both groups, society "as a whole" is to blame for the underrepresentation of women in technology related disciplines and careers.

Conclusions: In terms of confidence, frequency of technology use and positive attitudes towards technol-

ogy use there does not seem to be a big difference between WW and WD. Both groups do not hesitate to engage with technology and benefit from it. Nevertheless, there are differences in information and support needs. This might indicate that if this support is not provided many women with disabilities may remain excluded from fully benefiting from technology.

Keywords: Women with disabilities, Digital divide, Risewise project, Empowerment, Gender.

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Technology and Disability 31 (2019) S183–S188
DOI 10.3233/TAD-190013
IOS Press

Part 10: Digital Health

Telehealth Product and Service Design for an Ageing Population

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Background: This paper draws on research undertaken within the European Commission funded PROGRESSIVE project (www.progressivestandards.org) on 'Standards around ICT and Active and Healthy Ageing'. The project ran from 2016 to 2019. It raised awareness of design imperatives relating to products and services that are useful when accessed by or provided for older people. The focus in this paper is on telehealth i.e. 'the means by which technologies and related services concerned with health and well-being are accessed by people or provided for them at a distance'. Within telehealth's remit are services and technologies from social alarms and telecare to the Internet of Things (IoT), smart homes and wearables.
The paper signals some shortcomings in telehealth product and service designs that can be a consequence of patronising or ageist beliefs about older people; or arise through overly commercial orientations. Some commercial orientations may be associated with a view of older people as a 'market' to be exploited rather than as contributors to economic and social life (as workers, carers, entrepreneurs, innovators and leaders).
Method: The paper explores ethical issues that should appropriately be taken into account for telehealth product and service design if the position, needs and choices of older people are to be properly understood. It undertakes a comparative analysis of the 'ethical tenets' determined (following consultations with a 'task force' comprising seven older people convened by Age Platform Europe) in the PROGRESSIVE project, alongside other 'frameworks' and the methodologies that underpinned them such the PUX (Personal User Experience) guidelines (deriving from the work of the European Innovation Partnership on Active and Healthy Ageing); the Age of No Retirement Intergenerational Design Principles; the ISO 26000 guidelines on 'Social Responsibility'; and the work of the European Commission programme for 'Responsible Research and Innovation'.
Key results: The key outcome of the comparative analysis is a succinct ethical framework for telehealth that has wider relevance for health and related social care services. The framework is considered in relation to a 'telehealth change imperative' that seeks to harness, in positive ways, the disruptive impact of new technologies; and to facilitate people's access to and adoption of such technologies (and use of services) in new ways.
Conclusion: The paper argues that an appropriate ethical approach can underpin the role of telehealth in shaping future health services. It affirms that there is no 'doomsday' scenario of unsustainable services or a 'burden of care' because of the growing number of needy older people. Instead there is an opportunity for telehealth, subject to design considerations, relating to which

– through day to day technologies (smart phones, TV, wearables, etc.), older people are empowered by their access to information, employment and learning opportunities, social networks and more – including telehealth products and services;
– interoperable, accessible, usable, safe and otherwise well-designed telehealth products and services are available in ways that minimise intrusion and afford control by the older people who might wish to use them; and
– social norms are adopted that incentivise older (indeed, all) people to build their health literacy and engage in the management their health and related lifestyles.

Keywords: Telehealth, Standards, Ageing, Ethics, Design.

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A Digital System Supporting Effective Remote Multi-agency Home Visits

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Background: Unnecessary delayed discharge is a rising systemic problem. The total of delayed days in the UK has increased by 52% between 2014 and 2017, the majority being related to patients with chronic or life-changing conditions awaiting for a care package to be organised at home. Sheffield Teaching Hospital focuses on the "discharge to assess" paradigm, where patients are transferred to a community setting and then assessed. This requires mechanisms to coordinate the care between city council, hospital, social care etc. that incorporate services that select, install and support assistive technology.

Method: We created a telepresence prototype to securely perform remote home assessments, sharing of notes, recording/taking photos across services. At AAATE 2018 we presented the initial prototype. In this paper, we describe the final prototype developed following a series of stakeholders focus groups and PPIs. The process requires the patient, a registered volunteer or a relative based in the patient's home to connect via a smartphone to the Hospital. Video connection is provided via the browser, no app installation or subscription needed. The patients will receive a link to a webpage via text message or email. Clicking on the link will open a direct video communication with the service provider. During the visit, the operator is in full control of the remote phone and camera, being able to turn on/off the flash (torch mode), flip the camera, take screenshots and videos, zooming in and out to appreciate details, etc. All data (notes, pictures, etc.) are stored securely on a central server.

The system also supports physical home visits by enabling taking pictures and writing notes that are then sent to the central server, therefore becoming a one stop shop for all discharge information for both physical and remote visits. As the visit may involve different services beyond the hospital (e.g. care homes, social services, city councils, etc.), the technology supports simultaneous participation of multiple users from multiple locations. That can include remote family members. This enables:

1) sharing of essential care planning and information among services;
2) user engagement and personalisation of care, through the ability of involving patients and remote family/carers in decision making;
3) an easy channel for post-discharge follow-up.

Key results: We contribute to the "discharge to assess" paradigm by enabling effective remote visits, information sharing and continuity of care. We enable patients and carers to fully participate in a delicate phase of the discharge process.

Conclusion: We present a system for remote visits supporting effective remote multi-agency home visits, streamlining the service, making patient and family involvement a corner stone of the discharge process hence improving quality of care and outcome of the process.

Keywords: discharge to assess, remote monitoring, remote visits.

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ProACT: Person-centred Digital Integrated Care for Adults Aged 65 Years and Over, Living with Multimorbidity

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Background: At present in Europe there are 50 million people living at any one time with multimorbidity. However, our healthcare systems have not been designed to effectively support these people in their daily care needs. ProACT (Integrated Technology Systems for ProACTive Patient Centred Care) is a digital health research programme funded under the European Union Horizon 2020 framework that seeks to address this problem by developing and evaluating a digital integrated care system to support older adults (65 years and over) living with multimorbidity. This presentation will outline the main findings of the ProACT project where the daily experiences of participants living with multimorbidity were captured and responded to through the design of digital health solutions.
Method: Vital to ProACT, was eliciting the voices of people living with multimorbidity as well as the various people caring for them (formal/informal caregivers, health care practitioners). A co-design methodology was adopted, making these stakeholders active participants in the design of ProACT. Across Ireland and Belgium the following was conducted over a 42 month project period; a qualitative user requirements study ($n = 124$ stakeholders); co-design workshops and usability testing ($n = 60$ stakeholders); a 12 month longitudinal, action research proof of concept trials (involving $n = 120$ patients and their care networks). The primary trial sites were also supported by a transfer site in Italy consisting of 15 people with multimorbidity (PwM) and their care network, and a European transferability study was conducted to assess cultural, social, infrastructural, and political determinants for adoption and scalability of the system Traditional qualitative research techniques were combined with user-centred design methodologies to support the design, development and implementation of the ProACT digital system.
Key results: The main findings from the project will be presented, including the main themes that emerged from: the initial user requirements gathering (impact of multimorbidity; self-management; medication; knowledge, information and education; sources of support; communication; training; and technology); the co-design workshops and usability testing, which ensured that the ProACT technologies were designed to respond to previous themes; and finally results of the PoC trials, including themes pertaining to self-management, the ProACT ecosystem, integrated care, and empowerment
Conclusion: Conclusions will demonstrate how digital health solutions can improve home-based integrated care, supporting older people with multimorbidity to live independently in their community. Furthermore, this project illustrates how using existing Human Computer Interaction (HCI) and behavioural science methodologies can improve the design, development and implementation of digital assistive technologies focused on older adult self-management of health and well-being within multi-stakeholder and diverse ecosystems of care and support.
Keywords: Digital Health, Behaviour Change, Multimorbidity, Digital Integrated Care, Ageing.
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Advancing Home-based Integrated care for Older adults with Multiple Chronic Conditions: Preliminary Results from the Italian ProACT trial

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Background: A key challenge for healthcare systems in Europe is to improve best practices around the provision of continued, well-coordinated, person-centred care for older adults with multimorbidity (OAM). At present, however, most health systems still focus on supporting a single disease framework of care, thus resulting in suboptimal outcomes for the health services users. ProACT is an EU-funded project aimed at developing and evaluating an ecosystem to integrate a wide variety of new and existing digital technologies to improve and advance home-based integrated care for older adults with multimorbidity, including associated co-morbidities. In detail, the ProACT kit integrates a wide variety of new and existing technologies to improve and advance home-based integrated care for older adults with multimorbidity with a view to (1) improve self-management of chronic conditions, (2) promote behavior change, and (3) increase integration between and within health & social services. This study reports on the evaluation of the ProACT kit in the Italian context with a view to collect preliminary information on its usability and acceptability.
Method: The study followed a mixed quantitative-qualitative research design. In this contribution we report on the qualitative data collected. A total of 10 users (age range 65–83 years) were asked to use the ProACT kit in their homes on a daily basis. The basic ProACT kit included the following devices: a smart-

watch, a digital weight scale, and a digital blood pressure monitor. A tablet was given to the users to allow the visualization of the readings from the devices. Health professionals were also given the possibility to read each users' reading from a dedicated web interface. After 1 month of use, users participated in two focus groups to assess their views and experiences about the ProACT kit. A thematic analysis was conducted on the transcripts.

Key results: Three main themes were identified to explain how ProACT can facilitate self-management and behavior change as well as identifying the barriers to its adoption: Context, Process, and Outcome. The Context domain encompasses individual, family, and environmental factors. The process domain refers to procedural aspects of self-management, including specific behavior change strategies (goal setting, self-evaluation, and self-monitoring). The outcome domain includes short-term outcomes, such as successful symptom management and changes in health behaviors, which over time might result in distal outcomes, including reduced health system utilization and costs. To understand the potentials of ProACT to foster integrated care for people four dimensions of integration were further identified: Organizational, Functional, Service and Clinical.

Conclusion: The context in which this study was carried – as well as potential users of digital health technologies - seems to be ready to accept digital transformation of health and social services, providing that technologies are considered as a support to human activities and not merely substitutes. Technology should be designed taking into account diverse users' abilities and needs that can change over time. Context-related factors driving the organizational change needed to ease the adoption of digital health devices by all stakeholders need to be identified.

Keywords: Integrated care, ageing, digital health, behavior change

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Why do Dutch Older Adults Use Online Community Care Platforms, or Not?

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Background: The ageing of the Dutch population has led to healthcare reforms in which local governments encourage older adults to age-in-place and to self-manage their (health)care, if possible in collaboration with their social network and community. Prior research indicates that online communities can have a positive impact for older adults on civic participation, maintaining and developing social relationships and the exchange of various forms of social support. An example is an online community care platform (OCC-platform). Via OCC-platforms older adults can access applications that aim to support civic and social participation. The current study explores a Dutch OCC-platform implemented through an intensive user-centered process that took more than a year. Despite the efforts to implement this platform that fulfilled user requirements and conformed to important prerequisites distinguished by previous research, it was barely used by older adults. The purpose of this study was to gain insight in the experiences of older adults with the platform and their motives to adopt or reject it.

Method: In this qualitative study, three panels of older adults (N = 16) were interviewed in focus groups: 1) digitally skilled platform users, recruited online via the OCC-platform, 2) digitally poor platform users, recruited via a course about digital skills, and 3) non-users, who were members of a local activity-based group which was intensively involved in the implementation process but nonetheless chose not to use the platform. The Consolidated Framework for Implementation Research (CFIR) was used for the development of the interview guide and during the directed content analysis of the collected data.

Key results: The user-panels indicated that they barely used the platform and that it did not have any positive impact on their civic or social participation. Furthermore, all panels (users and non-users), predominantly gave motives for rejecting the OCC-platform, which was seen as: 1) externally developed, not accessible or user friendly and its information content as either outdated or as not matching expectations; 2) merely providing information one-sidedly and not as a two-way communication platform for facilitating civic and social participation; 3) intended for other people than themselves, i.e. "we are not old or frail". Finally, the

non-users explained their lack of engagement in the implementation process due to interference and influence of other stakeholders; the (implementation of the) OCC-platform was not viewed as a self-made choice but rather as imposed on them by professionals and municipality-agents.

Conclusion: The OCC-platform was largely rejected whilst it conformed to the user(-interface) requirements. Users were intensively involved in its development. We expected the platform to be usable, accessible and functional. The results invalidate these expectations. This raises fundamental questions about how to co-create such platforms and how to make sure they are used. Working with end users in the development process doesn't guarantee that the product actually meets a felt need. Future recommendations are: 1) to perform a comprehensive holistic study on the inner setting of a given community and 2) to employ 'out-of-the-box' methods to accomplish the latter, such as 'Co-creation' and 'Design Thinking'.

Keywords: ageing-in-place, online community platform, social network, civic participation, social support

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Opportunities for Multimedia Tools to Connect Care Services

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Background: Making use of digital technologies to support delivering AT through a remote service is occurring somewhat haphazardly. The rehabilitation field is already advancing remote services and its application in AT services needs to catch up.

ATs can be useful tools for meeting support needs when people are discharged from acute care. In many nations multiple care providers, other agencies, family and friends form the network of stakeholders in determining needs and solutions. The who, the way and the what of the services involved vary across diseases and disability. The nett result is that real world services are complex and often service users cannot directly participate in decision making, and AT needs to be considered alongside other interventions. Previously work has explored digital multimedia tools facilitating communication and sharing in the network but from the perspective of acute service discharge to people's own homes. Now what the technology could empower within current services, involving the perspectives of the community services and agents, is being investigated.

Method used: A collaborative and co-production qualitative approach is being employed. All the main stakeholder service providers within one city (3) are part of the team and guiding the engagement of their staff (N = 45–75) in focus group based workshops(3); in which, after introduction to the technology they can speculate and suggest how it might be useful in their routine practice. A synthesis from the workshop data will be reviewed by the project team and by service users. Indeed throughout service users have been and are being consulted to express their perspectives on the usefulness and acceptability of services/uses being suggested. All the stakeholder groups contacted so far have staff enthusiastic to take part – both in the collaboration and in the workshops. Three workshops have been held, 52 attended, this included members of actively supporting non-governmental organisations.

Key results: Whether service users (needing AT) have their needs assessed before discharge or at discharge from acute care having the direct involvement of the service users is highly desirable.

Preliminary analysis of the workshop data indicates that there are many potential novel uses and some suggestions for modifications to the technology have been identified; as expected there are some concerns about security and data governance. This approach is effective in triggering inventive and critical thinking for the use of AT in clinical practice. Early on the consultations outside the workshops have been important. For instance, the perspective of the social care service provider is very different and will significantly impact our final findings.

Conclusion: Embedding the research and development through involving stakeholders is empowering to answering real world challenges. However it also means that the challenges are more significant. Nonetheless, the positive attitudes and responses to involvement in the project are encouraging that multimedia tools will be acceptable to staff and there is an opportunity to improve intra- and inter- service operations and delivery of AT solutions.

Keywords: Multi-media tools, remote services, co-production, digital, communication.

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A Systems Approach to the implementation of a national model of Assistive Technology Service Delivery: Challenges and Opportunities Designing for the future: A Systemically Viable Assistive Technology Service for Disabled and Older People in Ireland

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Background: Irish Assistive Technology services have been under-resourced and inequitable by comparison with Australia, Finland and Denmark. This research sought to understand service delivery across education, health, employment and independent living, identify gaps, and establish the cost benefit of AT provision. The research sought to develop a systemically viable model for a coherent service, in a world characterized by Volatility, Unpredictability, Complexity and Ambiguity (VUCA), where public budgets are in flux, and technological advances are rapid, that understood the complexity of disability as a "wicked problem".
Method used: Soft Systems Methodology guided a systemic inquiry into current service levels: this included 15 stakeholder interviews and two group consultations using World Café methodology with 57 participants across state service providers, AT users, therapists, makers, academics and industry. Participants self-selected as members of a community of practice for AT. In accommodating the worldviews of different stakeholders, it became clear that a multifaceted approach was required that was flexible enough to respond to the complexity of disability and the diversity of people's circumstances and AT needs. It would need to encompass the whole journey from assessment to provision, training and follow up support. 3 case studies of individuals in different life situations were developed to establish a rationale for the cost benefit of an adequate AT service. They indicated the potential for significant savings if people are supported via AT to engage in education, work and live independently.
Key results: A qualitative analysis of current services indicated discrepancies in service provision and budgets nationally: there was a lack of clarity on how budgets were spent and the employment support budget was under-utilised. There was little evidence of cooperation across departments resulting, for example, in difficulties for people transitioning to take their AT from school to work. The research also indicated very different understandings of the relevance of AT: the Department of Education is forward looking in introducing AT at preschool level, yet in work support mechanisms are outmoded. Collaboration between different agencies is limited, with little political understanding of the potential of Assistive Technology.
Conclusion: The research confirmed that Ireland's AT services were sufficiently underdeveloped and siloed to require the design of a coherent national model. We proposed the development of an eco-system to create a comprehensive service to include a policy commitment from central government and a Central Co-ordinating Agency to take ownership of procurement, funding, co-ordination of service provision, training and information provision and create space for innovation in this domain. Included, is the concept of the AT Passport - a single resource to support Assistive Technology users to access the supports they need. The current political and policy environment points to an urgent need for the design of a central resource at a strategic government level. This is systemically desirable and is on the cusp of becoming an idea "in good currency". We also postulate that it has the potential to lead the way in redefining approaches to addressing other complexities of living with a disability in a climate-change world.
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Technology and Disability 31 (2019) S189–S193
DOI 10.3233/TAD-190014
IOS Press

Part 11: User Participation

Co-creation of Assistive Solutions

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Background: The working hypothesis is that collaboration of experts to define Ambient Assisted Living (AAL) solutions for people with disabilities is often difficult because the lack of a common language that would allow each one to state what is the problem and the solutions from their point of view. The interlingua that is proposed here is the use of videos, which are based on the use of simulations of daily living situations and technological solutions that can help to improve such situations. The communication among participants uses these simulations to support their understanding and discussion of the setting, and participants provide their observations in terms of modifications and annotations on these simulations. This workflow of interactions would facilitate arriving to a consensus on the problem's definition and the assessment of the solutions.
Method: The approach is multi-disciplinary as it involves the participation of different specialists (engineers for implementing the solutions, sociologists, psychologists, social workers) as well as the care givers (in many cases also relatives) and the end users. There is a combination of different methodologies from social sciences and software engineering. The flexibility of the process is supported by model-driven engineering techniques. This allows generating the simulations from graphical models that specify their different aspects (e.g. the activities or the space).
Key results: (1) A web-based collaborative platform that facilitates the discussion and agreement among experts with different profiles. (2) Case studies that will illustrate the use of the platform for modelling disabilities that are related with neurodegenerative processes. (3) Modelling languages that are adapted to experts of different specialties, in order to formalize existing knowledge in AAL that is normally partially recorded. (4) A catalogue of typical behaviours of persons and simulation elements that can be reused. (5) Guidelines, collaboration recommendations, and examples for using the platform and visual methods for the creation and validation of new scenarios.
Conclusion: The software tools have been distributed as open source and a website shows several case studies: http://grasia.fdi.ucm.es/hackwithpeople/. This platform supports a collaborative development of AAL solutions, with collaboration of all the interested stakeholders (e.g. final users, relatives, caregivers and experts). The use of videos as a mechanism to understand and discuss on the problem and present solutions has shown to be more effective than other traditional engineering tools (e.g., diagrams, technical specifications).
Keywords: Ambient Assisted Living, Simulation, Virtual Living Lab, Co-creation.
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Hackcessible: Towards a new model for stimulating user-led innovation in Assistive Technology

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Background: In recent years Co-Design or Participatory design methods have been mentioned by numerous researchers and developers as a preferred framework for product or service design and increasingly by those involved in assistive technology development. With increasing democratization of design and fabrication tools, we are also seeing many instances of assistive technology users themselves innovating solutions for their own needs globally and in many cases sharing these solutions online in an open source manner. Furthermore, hackathons and make-a-thons addressing

disability needs are gaining popularity the world over as a means to stimulate new innovation in assistive technology by leveraging the skills of the maker community, students and technology developers in a very short and intense timeframe. The authors have participated in and studied numerous models of such concentrated events focused on disability innovation and found significant gaps in need finding, user involvement and post-event sustainability of projects. The authors propose a new model for a disability focused hack/make-a-thon that brings together elements of participatory design and user innovation, along with a framework for sustainable technology & enterprise development beyond what is typically a weekend long event.

Method used: We present a case study for a hackathon /make-a-thon, along with a carefully curated programme of pre- and post-hackathon workshops that have been designed to both facilitate user led innovation and create opportunities for sustained technology development. In addition, at every stage of the process, we have surveyed participants to assess the effectiveness of this model.

Key results: Under this model over 75% of participating teams have developed prototype solutions that have been taken forward for either commercialization or as open source assistive technology projects.

Conclusions: By facilitating a collaborative user-led innovation approach between a diverse team of technology developers and technology users, and through a sustained process of co-learning, co-design and co-creation, we have developed a new model for stimulating and accelerating assistive technology innovation in hackathons that results in a greater probability of successful outcomes.

Keywords: Hackathon, Assistive, Co-Design, Co-Creation, Participatory

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Study on How Health Care Service Providers Together with Industry Partners Can Co-design Accessible Assistive Technology for Individuals with Intellectual Disabilities (ID)

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Background: The global drive to promote inclusion of people with intellectual disability (ID) into community living has had significant progress in the educational, social and occupational fields. The availability of quality digital education has been suggested in the literature to enhance the access of adults with ID to societal goods and their rights, enabling them to become active citizens. However only 1 in 10 people with disability who need assistive technology (AT) has access globally. For people with intellectual disability (ID), the proportion of those who need AT that have access remains unknown. This study aimed to offer evidence on how AT can be co-designed between health care service providers and technology industry partners to support social inclusion for people with ID. The study looks at an Erasmus+ funded Project DESKTOP with six EU country service providers working with Fundación Vodafone España, to co-design and build an accessible app Mefacilyta, to assist independence with diverse and transitioning service providers.

Method: The study used a cross-sectional comparative qualitative investigation focusing on the central issue of the role of AT in facilitating social inclusion and boosting equality for people with ID. Data were collected using face to face interviews between January to July 2017. Observations were used to complement any verbal data gathered through interviews. The study involved participants with diverse communication abilities, making it impossible to solely rely on interviews hence the use of mixed methods. Literature review was used to synthesize existing knowledge on how AT enhances social inclusion (access to services and interpersonal relationships)

Key results: The Mefacilyta App enabled the users to improve their ability to carry out various tasks with reduced support requirements. AT was seen to significantly empower its users to improve their independence and wellbeing. It was important to see how open the technology builder, Fundación Vodafone España, were to engage with the end users of the tool to ensure it was suitable for all. Participants in the present study were not only able to use the App to learn life skills but were also involved in how to improve the app to enhance usability enabling them to perform tasks that would have previously relied on support from others. One example how the users influenced the tool can be seen in the adoption of a more accessible calendar feature that now has text to speech integration. These additional features supported the autonomy of the users, it was a great boost for their self-esteem, sense of wellbeing and community inclusion.

Conclusion: Assistive technology can support inclusion for people with ID, particularly if there is collaborative co-development between all relevant stakeholders to ensure needs-based solutions. But access and usage barriers need to be overcome. Technology developers need to work directly with people with disabilities to co-design accessible solutions. Further research is needed to explore how best to ensure stakeholder engagement particularly how-to co-design with people with severe levels of ID.

Keywords: Co-Design, Assistive Technology, digital divide, user centered design.

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Assistive Technology Users at the Coal Face of Confronting Intrinsic Design Issues in their Assistive Technology

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Background: At the Technological University of Dublin a Product Design programme students, and members of the Disabled Community (Assistive Technology users) have teamed together to create a unique multidisciplinary learning environment for Assistive Technology and Universal Design. Finally, this paper will show the outcomes of various student feedbacks highlighting the observed benefits of this approach.

Method: Having discussed design with AT Users students realise very quickly that AT devices are not the 'panacea for all ills'. Indeed the challenges of using 'off-the-shelf' generic AT devices becomes immediately clear, as people with varying degrees of disability experience difficulty adapting to and using these generic devices. Remarkably there is a reported abandonment rate of 78% for certain AT technologies. Students are encouraged to keep this notion of abandonment very much in mind when they are developing their design concept, and they are encouraged to (and supported by Enable Ireland) engage with both clients and staff, to seek their feedback, on their emerging designs. The students have complete freedom with the AT design, but are expected to draw upon theoretical concepts delivered in class in order to support their ideas. It is expected that the design will be responsive to client's needs.

Key results: An important aspect of this multidisciplinary approach is that everyone involved recognises that people with disabilities have the same aspirations to independence as their peers, this partnership sought to address the inequalities that exist in some product design which limit their use, and to identify novel design concepts which would enhance autonomy and independence for participants and for the wider community. interact extremely well with clients, and develop good working relationships. Clients report favourably on students, and enjoy the special attention that the project confers upon them. As a result, successive groups of students are encouraged by their community engagement and have been inspired towards community engagement/design after graduation. During a survey the students answered the following question: "How much has this experience changed your perceptions of design?" The mode response was 100% and the average response was 83%. In this journey from theory to practice, through engagement with clients, students learn about responsive design.

Conclusion: This approach has outcome and impact, both on the student and the community that is pervasive and far-reaching. While on the one hand the outcomes of this element of the module appear modest (product design), the enactment of this results in a powerful and emotive journey for the student, one that not only promotes learning in the real world, and engages and empowers community partners, but has fostered the development of influential partnership across industry and practice. Through the fostering of community relations, and building relationships between industry and the third level organisation that this module has created, pathways have been developed that pave the way for the Engineering community to positively engage with AT design and national disability services that can have far-reaching consequences and raise awareness of the need for Universal Design.

Keywords: Universal Design, Community, Engagement, Assistive Technology, Enable Ireland.

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Enabling User-centered Design and Evaluation to Increase Acceptance of Wearable Robotic Assistive Technologies

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Background: With wearable, lightweight and more affordable robotics on the rise, new opportunities for daily life assistance for people with neuromuscular disorders become available. However, the successful application of a device stands and falls with the respective user experience and technology acceptance. Unfortunately, the majority of promising research prototypes underestimate these obstacles or fail to consider the human factors confounding assistive technology usage. User-centered design (UCD) of assistive technologies has shown to remarkably increase user experience. An intensified target population interaction with early prototypes can potentially provide valuable insights to overcome the gap between in-lab testing and clinical or home application. However, understanding and analyzing user experience is not yet sufficiently established, lacking clear guidelines and standardized measures. This generates difficulties to define requirements and assess device performance, especially in the emerging area of wearable robotics. There is a need to simplify and enable the user-centered evaluation and design of assistive technologies to successfully tackle the prominent acceptance limitations.
Method: We propose a UCD framework for wearable robotic assistive technologies, addressing three specific aspects currently limiting the success of UCD design processes: (i) planning and preparation, (ii) context and needs assessment and (iii) user testing and evaluation. To understand the current limitations of UCD, surveys are being conducted with development experts, health care professionals, caregivers as well as end-users and their next of kin. With this collection and repository of knowledge, an improved understanding and assessment of user needs in the context of device usage can be proposed. Through contextualization, we define required stakeholder involvement milestones during development and achieve a more targeted selection of user experience measures. A UCD toolbox selecting and proposing standardized outcome measures from an online database is currently being established, with the aim to define comparable evaluation protocols with appropriate measures fitting the context of use. A preliminary version of the UCD framework was tested to evaluate and redesign the physical human-robot interface of the VariLeg powered lower limb exoskeleton, involving two experienced paraplegic users.
Key results: The UCD framework under development aims to provide standardized, context-specific outcome measures to (a) assess end-user experiences (b) identify key limitations and (c) provide more generalizable usability results when testing wearable robotic assistive technologies. The enhanced feedback from the evaluation phase can be used to further refine the context and needs assessment and initiate the next design cycle. In our research with the VariLeg gait exoskeleton, this has shown to facilitate target population involvement and motivated the iterative design of individual interface components, leading to an increase of 45% in the perceived usability, measured by the System Usability Scale (SUS).
Conclusion: Acceptance limitations of novel assistive technologies are aimed to be tackled with a simplified UCD approach. Maximizing user experience relative to the context of use can help to close the gap between in-lab testing of research prototypes and real-life application in daily usage. This can not only increase development efficiency but, more importantly, increase the quality of life of those in need of technological support.
Keywords: User-centered Design, Assistive Technology, Wearable Robotics, Usability Evaluation
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Benefits Beyond Experience

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Background: Many organisations provide digital accessibility services. Management generally view accessibility as benefiting a handful of their user group. They question the 'Return on Investment' on money spent on accessibility compliance. When an organisation truly embraces accessibility, not only do we meet local legislative and International human rights obligations, but we reduce costs, and build our internal capacity for design and innovation. Clients become our partners in building for universal design and build partnerships with their customers, continually creating delightful user experiences. In our observation of various organisations and their approach, we have located a set of characteristics of the organisation taking the road less travelled to embrace accessibility organisation-wide.
Method used: Our work is observational, based upon experience with a broad range of clients from federal government to not-for-profit. Using our Digital Accessibility Maturity Model (DAMM), and working with organisations we assess their placement on the DAMM

from 0 – no knowledge/application to 5 – embed digital accessibility into all projects, products, processes and business management. The characteristics and experience of the mature organisation demonstrate there are benefits in becoming accessible beyond that of the practical interaction of the user with disabilities.

Key results: The organisation placing highly on the DAMM looks beyond a technical compliance/checklist mentality. Compliance is only as good as your ability to ensure that the philosophy is embraced and all new content is tested to ensure compliance. There will always be issues out of your control – such as user-generated content and difficulty locating accessible third-party products. The mature organisation incorporates best practices into its culture and practice, making it part of their standard operating procedure. They prioritize people with disabilities when making design decisions. Accessibility is integrated into training and education programs. They test to ensure that users of assistive technology are able to have a seamless experience, as equivalent as possible to that of the person without disability. When accessibility is viewed by the mature organisation, they see benefits beyond that of the user's individual experience. When a user has a great (accessible) experience, it is not just the fact that they are able to accomplish a task. One example is the user tester who had such a good experience with a local government website she stated "it made me want to move there". There are benefits beyond user experience, such as public relations, customer referral, leadership and reputation. The organisation approaching the more mature end of the continuum by incorporating diversity into their hiring practices, ensures all digital material is accessible, and looks for ways to show leadership.

Conclusion: The more mature organisation, sees the benefit of incorporating the needs of all of their users into their design as well as into other aspects of their organisation. They realize that meeting the needs of people with disabilities allows them to create a better experience for all of users. They approach accessibility as an opportunity to create a new and more satisfying type of interaction with their user – one that goes beyond compliance with a standard.

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Technology and Disability 31 (2019) S195–S198
DOI 10.3233/TAD-190015
IOS Press

Part 12: Internet of Things

Universal Controller: An Open Source Software Development Promoting Connectivity with Assistive Technology Devices and the Internet of Things

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Background: The Assistive Technology (AT) market will surpass $26 billion by 2024 (Forbes, March 2017), with over 1 billion people globally requiring assistive products. This sizeable market is wide ranging and disparate due to the diversity of the end user needs. Successful development and application of AT products for people with disabilities is made difficult by the complexities of the market.

The Internet of Things (IoT) equipment market is estimated to be $520 billion by 2021 (Forbes, August 2018). The explosive growth of the IoT is due to its potential to connect things-to-things, people-to-things and people-to-people. However, few IoT developments take into consideration people with disabilities. There are IoT connectivity solutions available for some products but there is a lack of connection with AT Input Devices. Hence, the benefits of IoT are still yet to be leveraged to its maximum potential in promoting independent living.

There is a need for an open source software package capable of linking AT Input Devices to any connectable device using programmable settings to allow flexibility for users. Such a system would enable the development of new AT devices and provide accessibility to IoT devices for people with disabilities.

Method: At the request of children's charity Wooden Spoon, a multidisciplinary team of undergraduate students at Imperial College London developed an open source software platform to allow the control of output devices via a variety of AT Input Devices in a plug-and-play fashion. The software is built as a web or desktop application so can be used on any computer or smartphone. Users can use their own specific input devices such as buddy buttons, puff and suck switches or eye trackers to control a variety output devices all via one application.

Key results: Three demonstration projects were developed using the system to show its potential:

1. Control of a Phillips smart lamp,
2. Interaction with Alexa using a Tobii eye tracker to type commands,
3. Control of a robotic arm using an AT joystick through the interface.

A demonstration was run for the staff at the Ace Centre, a charity specializing in AT, this provided positive and insightful feedback which highlighted the importance of accessibility of the system settings and enabling customization by the user to meet their needs. These concepts where then were integrated into the following iteration of the system. The feedback indicated that the system would have value to users, developers and suppliers.

Conclusion: A platform technology has been developed which enables the connection of conventional AT Input Devices, such as joysticks and buddy buttons, with IoT connected Output Devices, such as smart lamps and robotic arms. The aim is for this software to be released under an open source licence to allow users free access to it and to promote further development and connectivity within the AT field. A successful proof of concept demonstration was delivered in the first phase of this project with three examples of its ap-

ISSN 1055-4181/19/$35.00

plication. The development is to continue in partnership with the Apperta Foundation.
Keywords: Control, Open Source, IoT, Connectivity.
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Implementing an IoT Based Task Analysis System to Promote Autonomy in Daily Hygiene of Adults with Autism in a Residential House

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Background: The Internet of Things, IoT, has been increasingly gaining attention in educational contexts because it allows to connect physical objects through a network to enrich users' experience. Recently, particular attention has been placed to wearable objects, accessorizes provided with intelligent devices, such as beacons: usually bluetooth devices able to transmit and receive signals within short distances. IoT can improve the lives of people with disabilities. A good quality of life must include the possibility of being independent in all contexts and activities such as personal hygiene, dressing and undressing activities, moving in space. Unfortunately, autonomy is often lacking in people with autism.
To support the learning process of daily living activities of people with autism, it is important to facilitate a task, for example through a task analysis that analyzes and describes the sequence that composes an action, in the logical order for its correct execution. Our purpose is to verify whether wearable intelligent objects, complemented with a task analysis system, can be used, in a residential context, to facilitate everyday hygiene in individuals with severe autism.
Method: Participants will be 2 adults with severe autism. A single-subject study was chosen because it is more suitable for the development of technologies for severe disability. The experimentation will take place in the Residential Section of the A.I.A.S. Center (Nola, Naples), which offers a suitable housing solution. The essential tools for the study will be the beacons, produced by the Estimote company and already used in the center, and 1 10-inch tablet containing a software for task analysis. The task analysis will consist of a subdivision into small steps of daily hygiene tasks, such as brushing teeth. Whenever the participants will enter the bathroom, the tablet will retain the sensor signal and activate by playing on the tablet videos of all steps of the task. The participant will be able to observe the sequence and asked to reproduce it.
Key results: We expect that the beacon system, complemented with the task analyses software, will facilitate the daily hygiene skills of participants with severe autism, thus favoring their personal autonomy, and gradually helping them to generalize these skills in other contexts.
Conclusion: Internet of Things will impact on our everyday life. Those who already have some devices, connected to the Internet, already appreciate the possibility to remotely control their own home devices. However, we think that more advantage can be gained by people with special needs.
The purpose of the residential structure is to implement a global therapeutic, rehabilitative and educational life project. The use of the IoT system allows the person to take advantage of the help of the surrounding environment for accomplishing his specific task without relying on the human operator. The final goal of our work, however, is to promote independence also from our system, in fact, once individuals will succeed in their tasks the artificial support will be gradually removed to let them back to their usual contexts with new skills.
Keywords: IoT, Task Analysis, ASD, Beacon, Rehabilitation.
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The use of Internet of Things (IoT) and Assistive Technology (AT) in developing 'Smart Homes' for health and social care in the UK

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Background: Consumer smart technology is a rapidly growing industry and becoming increasingly present in our day to day lives. The convenience this presents is hugely beneficial, but it can be utilised in a far more valuable way; to increase the independence of individuals with physical or cognitive disabilities in their homes, as well as monitor their lifestyle to assist in

their care. However, using this technology in an assistive way to build an ecosystem of smart devices and sensors using Internet of Things (IoT) technology is an unfamiliar concept, unknown to both health and social care providers and the general public. The digital infrastructure required to realise this idea is also not currently available to the majority of regional care providers in the UK. This paper presents a case study where assistive technology and IoT are being used to address the challenges of providing health and social care in Barnsley Metropolitan Borough Council.

Method: The aim was to simulate a smart-home test bed that can demonstrate to care providers across the country, the capability of consumer IoT technologies and the benefit they provide to increasing the quality of care. Initially, interviews were conducted with members of Barnsley Council and health and social care professionals, as well as research to explore the multifaceted capabilities of consumer technologies to aid with lifestyle monitoring and residential assistance. Key target areas were identified based on the proportion of resources being spent on health and social care. Within this study, a scale physical model of a smart home was created, containing sensors to mimic current consumer technology. This model house served as a testbed that facilitated easy and quick simulation in a number of configurations. These sensors were evaluated on their ability to fulfil the monitoring needs of patients with frailty, dementia, learning disabilities, and mental health issues. A feasibility case was also built to help catalyse the process of implementing these new technologies amongst the services of healthcare providers across the country. Finally, an IoT digital framework was designed which would be accessible to prospective patients and social care bodies, working on a feedback loop system to provide information about the optimum technology available to suit each need.

Conclusion: The future of residential healthcare may lie within the optimisation of AT using IoT. In this study, we are developing this through linking a digital IoT framework with data collected from a simulated smart home environment. Although this study is only the first step towards a more efficient system, we believe that IoT may be integral to providing patients the independence they may not currently be receiving.

Keywords: IoT, residential-healthcare, smart-technology, lifestyle-monitoring, alzheimer's

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Waking-up in the Morning: A Gamified Simulation in the Context of Learning Activities of Daily Living

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Background: The degree of child independence in Activities of Daily Living (ADLs) is crucial for parents, caregivers, educators, and therapists. Achieving basic skills is vital not only for children with developmental disabilities but also for typically developing preschoolers and primary school students. People with developmental disorders often have difficulties while performing ADLs, (e.g. dressing, cooking, cleaning and personal hygiene), whose acquisition leads to increased independence; therefore teaching focuses on conveying functional skills.

The relevant literature suggests that children with developmental disabilities face the following difficulties:

- comprehension of symbolic play and pretense
- low imagination level
- resistance to changes to their environment or daily routines
- limited ability to identify with others
- trouble applying what they have learned to real life

Three instructional approaches are commonly applied to promote daily living skills: (1) *in-vivo instruction*, (2) *video-based instruction (VBI)* and (3) *computer-based intervention (CBI)*. The problem with all three approaches individually is that application of taught skills to real life is very difficult for children with a limited ability to identify with others.

In order to overcome this difficulty, we are designing and developing an interactive simulation game called "*Waking-up in the Morning*" with image fidelity to ensure natural representation and better transfer of skills to real-world conditions. Our research questions are listed below:

- can the game function as educational material in the context of ADLs, both for students with special educational needs and their typically developing peers?

– can gaming become the bridge between children regardless of their cognitive profile, promoting collaborative learning through peer-mentoring?

At this stage, alongside the game development per se, several of its aspects are examined (e.g., gamification techniques and interface design), taking into account users' evaluations and feedback (students with developmental disabilities and typically developing students) and game design experts.

Method: Our main goal is to investigate transmedia learning in inclusive conditions through gamified content that combines the three instructional approaches (*in-vivo instruction*, *VBI* and *CBI)*, traditional gaming modes and cutting-edge technologies: cards, virtual/augmented reality and 360° interactive videos. VR-enabled headsets, laptops, tablets, smartphones and interactive whiteboards will be used, depending on the player-learner's characteristics. Our literature review establishes the benefits that emerging technologies bring to individuals with special educational needs, as well as obstacles they face in the use of VR devices, which are necessary to support novel gaming methodologies. The target group combines typically developing children aged seven years old and individuals with developmental disabilities of similar mental age. The simulation game will be tested in inclusive environments in general schools.

Conclusion: The purpose of this paper is to present our alternative approach, game design and production for teaching ADLs using cutting-edge technology. In the near future, we will examine if the proposed simulation game can be used to support different learning styles and differentiated instruction. The ultimate goal of the research is to suggest good practices in the field of gamified and highly interactive digital learning materials for the implementation of inclusive education.

Keywords: Activities of Daily Living, Interactive 360° Game, Simulation, Transmedia Learning, Virtual/Augmented Reality.

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Technology and Disability 31 (2019) S199–S202
DOI 10.3233/TAD-190016
IOS Press

Part 13: (e)Accessibility

Accessibility Equals Innovation

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Background: For people with disabilities, assistive technology (AT) is a necessity. AT is often prohibitively expensive for people with disabilities, especially new technology. If we can influence creators of AT of the opportunities for innovation through a Universal Design approach, the lives of people with disabilities will be improved, and appeal to a larger segment of users. While AT has largely come about through innovation to solve a particular need, that innovation has provided benefit for an unintended group of users. AT is largely seen as confined to people with disabilities, however, incorporating Universal Design principles broadens the commercial potential, making it more affordable. Developers should understand that meeting a particular user group's needs, provides an opportunity to benefit a larger user group. The role of Universal Design in AT, encourages design for a wider audience, encouraging innovation and enabling more economic solutions for accessibility issues.
Method used: We observe AT employed by our user testers, and see that what is essential for them, is now being used for different purposes. Technology such as eye-tracking and voice-activation software, was developed for people without the use of their hands to work with digital material. Eye-tracking is now being used to predict user behavior to determine the best placement of material. Voice activation, is being used by professionals, decreasing the time and cost of dictation/transcription. The principal of Universal Design shows that developing technology that will be usable by a broad group of users broadens the commercial potential for the technology, which may lower the cost and ensure better support than technology intended for more specific audiences.
Key results: Developing AT for people with disabilities has led to opportunities for innovation. Not only does the wheelchair ramp benefit someone in a wheelchair, it also benefits the mother pushing a pram. Global initiatives, such as the WHO's GATE program are looking to provide access to assistive technology for everyone, enabling the person to lead the type of life they wish. Embracing innovation which benefits the wider society, benefits more than people with disabilities. Incorporating the concept of Universal Design to create more accessible digital environments need not diminish the emphasis on the needs of people with disabilities. Enforcing accessibility meets with reluctance, though it is intended to make life better for people. If we were to change the motive for developing products to meet a wider possible audience, there would be greater commercial interest, and hence more innovation to assist users with disabilities.
Conclusion: AT is not a 'nice to have, for a minority of people', it is a necessity for many. Incorporating Universal Design principles into AT development provides an opportunity to develop products that delight a wider audience, while also meeting the needs of people with disabilities. The practical implication is that if we change our mindset about the audience for technology advancement for people disabilities, we have an added commercial incentive to sell products that improve lives for a wide range of people.
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Complex PDF Remediation for Accessibility: Review of Current Methodologies

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Background: There is a growing demand to remediate complex non-accessible PDF. For instance, schoolbooks which are required to be accessible and show a wide variability in their morphology. A problem lies in the existence of an extensive bibliography of digi-

tal teaching material that are delivered using PDF not accessible. Currently the tasks involved in making a PDF accessible are expensive due that many of them have to be performed manually. Among these, structuring PDF content is especially time-consuming. Tagging i.e. associating a label to each significant element of the document, is a prime example thereof, as it is of uttermost importance in order to enable assistive technologies, such as screen readers or accessible forms for motor disabled people that do not use analog pointing devices. The question that arises is whether it is possible to make this process cheaper. To do so this tries to identify the current needs in the remediation procedure to enable a following research about improvements.

Method: In a first stage, a comparison is made between the current PDF reading and authoring tools. The selection criteria for the software to be compared is, its popularity and it must be intended for an individual user using a PC. This filter keeps out little-known software that professional of the document accessibility remediation seldom use, and also online remediation services that often not to allow public access to their internal procedures.

In second stage, it is chosen one tool. With this, it is analyzed the procedure to make PDFs accessible. The effort is measured using the amount of steps, the number of user interactions to achieve each step and the obstacles and inconsistencies found in the workflow.

The documents used in the second stage are non-accessible PDF schoolbooks. Since these meet the requirements of complexity and need for remediation.

Key results: Acrobat Reader DC is chosen after analyzing the comparative. The main reasons are that Acrobat is de facto desktop application for working with PDFs, other software describe a procedure for remediation quite similar or need the use of Acrobat in some steps. It worth mention that many analyzed tools are not able to accomplish completely the procedure of making accessible PDFs.

Results show that Acrobat is not optimized for accessibility remediation. The user has to perform complex manual actions very often. Automations offered by the software are useful and save time and effort, but fail when the complexity of the document increases slightly. Many times, correct the results of the automations involve doing greater effort actions than the necessary ones to accomplish procedure in a completely manual manner.

Conclusion: The process of fix the accessibility of PDFs can be improved using a tool designed specifically for this purpose. Acrobat DC may be a good choice for the remediation of documents with simple structure, but not in other case mainly because poor results of the automated task. Therefore, there is room for future improvements in the automation of tasks for the treatment of complex documents.

Keywords: PDF, Accessibility remediation, SOTA, tool comparison, teaching material.

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Holistic Evaluation Method and Tools for Local Government Websites Case Study: EEC, Thailand

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Background: Eastern Economic Corridor (EEC) locates in the Eastern part of Thailand, which should facilitate the Thai economy in the long run. Thai government sets this area to be the heart of national innovation and technology development. While the economic aspect is the main target, the social aspect is also important due to the great number of estimated migrant workers (more than 33,000). Currently, local governments set up their own websites providing information and e-government services; including relocation, registration, ID card extending, etc.

Since the variety of the potential users is tremendous, these websites have to universally usable and accessible. There are works tried to evaluate Thai government websites. However, they only covered evaluation partially, without consideration of social and economic aspects. The aim is to identify factors that affect the accessibility, usability, and user experience and combining each factor and its testing method into an area-based holistic evaluation method, which covers 4 areas including Availability, Mobile Device Readiness, Accessibility, and Usability.

Method: The most important 10 local governments' websites are selected for evaluation in our laboratory.

The availability is defined through a web content download speed over slow Internet connection, reachability upon multiple requests, web content display ability, and security issue. For testing, a semi-automatic testing toolset was chosen: the Google Chrome Development Tools. These tools are used for different Internet connection speed simulation, secure protocol HTTPS, and meaningful page load checking. The mobile device readiness is defined through meaningful re-

sponsive web design for small displays. The Google Chrome Development toolset is used to simulate a website in different screen sizes. The accessibility of a website is tested using the W3C Markup Validator and WAVE from WebAIM. The first one is used to check HTML implementation. The latter is used for accessibility testing against WCAG 2.0 level AA. Furthermore, a color contrast between foreground and background colors is examined. The standardized heuristic evaluation for user interface design, suggested by Jakob Nielsen, is used for usability testing and it contains 10 usability criteria, which is evaluated by experts.

Key results: In terms of availability, only 3 out of 10 websites passed the speed test, and none of them uses secure protocol. For mobile device readiness, 3 websites can be considered as ready due to their meaningful responsive design. For accessibility, only 4 websites have errors less than 50. Most of them have a high number of programming syntax errors. And for usability, none of the websites can reach the highest score. Furthermore, 60% of the websites use Flash content only for decorative purpose.

Conclusion: For evaluating local governments' websites by means of supporting economic and social aspect, different factors and evaluation strategies have to be identified and tested. We suggest 4 evaluating aspects (Availability, Mobile Device Readiness, Accessibility, and Usability) for local governments in EEC area. The combination of evaluation factors and methods can be used as a standard strategy for evaluation. The next step is to provide a handy toolset and manual for standardized Thai local governments' website evaluation.

Keywords: Website, Accessibility, Holistic, Government, Evaluation.

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Usability Assessment of an Accessible Voting System – A Mixed Method Study

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Background: Persons with disability have fewer opportunities to participate in politics, including voting in elections. There is a lack of information about the participation levels of persons with limitations in fulfilling the ballot in paper. Although in some countries it may be possible to use alternative forms, such as voting accompanied by another person, there is still no system to guarantee the person's independence in completing the ballot paper in a secret manner. This experimental study aimed to evaluate the usability from the point of view of the user of an Accessible Voting System (AVS) in a real election.

Method: A parallel mixed method study was conducted in the Executive Board election of Oporto's Cerebral Palsy Association, Portugal. From the seventy total voters, thirty-one adults (twelve with Cerebral Palsy, GMFCS: I–II = 5; III–V = 7) that choose to vote using the AVS were included (19 males, aged between 24–73 years old). The AVS comprises: (i) a computer application with voting options; (ii) visual and auditory instructions for the user; (iii) different input methods like touchscreen or scanning; (iv) different simultaneous output methods such visual or auditory; and (v) a printer for produce an individual secret ballot paper. A quantitative usability assessment was made using Post Study System Usability Questionnaire (PSSUQ) that comprises 19 items (1–7 Likert scale, 1 = better usability). In addition to a global score, PSSUQ provides results in three domains: (i) System Usefulness; (ii) Information Quality; and (iii) Interface Quality. Qualitative data of persons with Cerebral Palsy was obtained through a structured interview covering: (i) previous experiences of voting; (ii) what was the sensation of using the system; and (iii) recommendations for improvement.

Key results: Global usability score for PSSUQ was mean = 1.3 (dp = 0.35). For subscales System Usefulness, Information Quality and Interface Quality scores were mean = 1.1 (dp = 0.30), mean = 1.2 (dp = 0.55), mean = 1.5 (dp = 0.80), respectively. No difference was found in scores between Cerebral Palsy voters and other users. In the same sense, no association was found between PSSUQ results and age or gender. From users with Cerebral Palsy, two never had voted before, eight used to vote accompanied by another person and two by themselves. The sensation of using the system was described as: [A] "System is accessible and practical in use."; [B] "More autonomy."; [C] "Easier than manual voting."; [D] "[...] because I went alone, it was good do not have to take anyone with me, it should be implemented at the national level [...]."; [E] "I felt it was easy to understand."; [F] "A freedom, so the vote is 'more' secret, nobody knows.

Must be this way to vote for the Government."; [G] "I felt I was doing a normal act of citizenship. I think it should be implemented all over the country."; [H] "It was my first secret ballot [...]."; [I] "I feel very well and comfortable, it's very easy.".

Conclusion: The results shown a high level of usability of the AVS and can contribute for this kind of tools to be made available in national and European elections. Other more in-depth studies should be carried out, including in other populations, in order to confirm the results.

Keywords: Accessible voting system, Usability assessment, Mixed method assessment.

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Technology and Disability 31 (2019) S203–S205
DOI 10.3233/TAD-190017
IOS Press

Part 14: Platform Speeches

Bridging the Gap Between Research and Practice: Investigation of Needs and Characteristics of End-users, for a Future Inclusion of BCIs in AT-centers

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Background: Brain computer interfaces (BCIs) measure signals related to specific brain activity and translate them into outputs to control external devices. It is demonstrated that BCI can provide people with communication disorders with an Assistive Technology (AT) restoring their interaction with the environment. Despite BCI technology could improve inclusiveness of AT solutions, BCIs are not currently available in the AT-centers portfolio. A step forward the inclusion of BCIs in AT-centers, is their integration with existing (available in the market) assistive or mainstream technologies, resulting in a hybrid BCI-based communication device. The aim of the study is to investigate the characteristics of patients attending an AT-center, who could take advantage from BCI introduction in AT-centers as an additional/alternative AT channel. We believe that a step to bridge the translational gap between BCI development and end-users, consists in the clear definition of users' characteristics and their ability to control a BCI.
Method: Ten patients (43.3 ± 9.9 y.o., 2 men) with different diagnosis participated in the study. All patients had undergone a multidisciplinary evaluation and an AT training in an AT-center, because they were limited in (at least) one aspect related to interpersonal communication and/or interaction with digital technologies. Protocol consists of two part . *i) Need assessment:* patients were administered with the Individual Prioritized Problems Assessment (IPPA) to investigate their needs and they were involved in an AT training aimed at identifying the AT solution matching them. Patients agreed to participate in the BCI session, which will be performed in the next weeks; *ii) BCI session:* scalp potential will be acquired by means of 16 active electrodes. A P3-speller interface (a matrix of alphabetic items randomly flashing) will be displayed. Patients will be asked to spell words by focusing attention on the desired items. The Tobii Technology 4C eye-tracker will be used to collect eye-gaze data.
Key results: Fifty-eight problems in total were identified, with an average of 6 (5.8) problems for participant (SD = ± 1.9; min = 1, max = 7). Problems most commonly reported concerned "reading/writing" (N = 8 patients), "communication" (N = 7 patients) and "phone access" (N = 6 patients). AT solutions included touch screen (N = 4), head tracker (N = 2) and eye tracker (N = 3) as input channels to control customized user interfaces. Relationship between patients' clinical and neurophysiologic (ERPs) characteristics and BCI control performance will be reported. Influence of eye-movements will also be reported.
Conclusion: In this study, we reported preliminary data about needs and matching AT solutions of potential end-users of a hybrid-BCI device for communication. The overall aim is to generate profiles of patients that would potentially use the BCI as an additional/alternative channel for AT. With this aim, in the next step, patients' performance in controlling a P3-based BCI will be investigated and the relationship with user's characteristics (clinical and neurophysiological) will be established. We consider this as an important step for the integration of BCI with daily AT devices (personalized hybrid BCI) and for BCI inclusion in the AT-centers portfolio.
Keywords: Brain-computer interface, communication, users' need, hybrid, eye-tracker.
Acknowledgement: This work was partially supported by the Promobilia Foundation (Grant Ref. 17137).

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Environment and People Perceptions: The Experience of NEVArt, Neuroestethics of the Art Vision

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Background: For several years, neuroscience has been involved in understanding the neurobiological bases of how people perceive their space and every common activity and to change organizational and architectural tools, to brake the existing barrier for a universal designed environment. Dues to the difficulties in using medical devices outside laboratories, scientists simulated their scenarios. The obtained results followed the classical view of cognitive science, which considers the brain as a machine that processes stimuli in a hierarchical way, at different stages of complexity. The chance of conducting real field studies is now easier through the increasing availability of low size sensors and wireless networks for EEG and EMG analysis. The same for other physical and physiological parameters, such as the tracking of eye movements and the electrical conductivity of the skin, closely related to the individual's most instinctive and unconscious reactions.

Method: The NEVArt project wants to investigate a typical emotional feature, as the evaluation of the artistic production and the wide aesthetic involvement generated by the vision of an art work, using a scientific approach and a statistically relevant amount of data. The research aims also to compare and evaluate both the medical and signal affordability of data generates by new Wi-Fi tools, often developed outside the health field (i.e. video games, meditation skills, mental-physical sport performance, etc). The first research step is to analyse how the brain perceive emotions in real scenarios, to further exploit this information improving the architectural environment, the way of exhibiting art and the approach to people that, dues to their specific background or physical-mental capacities, perceive some elements as a barrier or an improvement (to understand or to be understood). The NEVArt research group (including neurologists, engineers, architects, psychologists, ICT and art experts) will detect the aforementioned parameters by monitoring volunteer (at least 600 people) to analyse their explicit and implicit reactions using different kind of sensors, during their visit to the exhibition "*Painting affections: sacred painting in Ferrara between the '500 and the '600*"', set up at the Estense Castle in Ferrara from 26 January to 26 December 2019. The study database include: records collected by the investigator upstream (crowding, thermos-hygrometric context, lighting, noise, etc.), non-sensitive and anonymous data filled in by the voluntary visitors in the first section of a questionnaire (age, schooling, habit of attending exhibitions, interest in the subject, level of fatigue/initial fatigue, etc.); subjective evaluation by the volunteer of the works viewed (in the second section of the survey); the tracks of each analysis tool worn (including the video made in real time with the eye tracker). All data will be uploaded at the end of each working day by the investigator, within a protected database (created by CIAS and already used for other similar clinical surveys). All the recorded materials will be periodically analysed and statistically re-elaborated using T-test and ANOVA, by the research group, relating objective data (collected with sensors) and objective data (entered by the participant and the experimenter), so as to assess the incidence of elements of agreement and/or dissonance.

Key results: NEVArt may provide a framework of people's physiological, neurological and cognitive emotional reactions, on a broad statistical basis, during the vision of art (now painting but following sculpture, architecture, etc.). The main NEVArt aims are:

1. obtain a neurobiological validation of the experience of aesthetic perception, with particular reference to bodily and mental involvement (neurovegetative, motor, emotional), both implicit (from EEG, galvanic) and explicit (from survey), facing the artistic work and testing the possibility of calibrating some of these sensory levels (disgust, indifference, pleasantness, etc.);
2. quantify the intensity and type of instrumental signals recorded as a function of the level of aesthetic perception, comparing the obtained results through multisensory EEG, EMG and eyetracking tools in real museum conditions (Scenario A) and with high sensitivity EEG 64 channels sensors, EMG and eyetracking for a limited number of paintings and using a low environmental stimulation (Scenario B);

3. to identify the descriptive parameters of the cited experiences, in order to create a significant scale to represent the physical, emotional, cognitive responses on external strains, referable to the art vision.

Conclusion: Due to the CIAS experience on large clinical surveys, the collection of a huge amount of data it's extremely useful to consolidate the information collected through different sensory channels and diverse tools. Using this method, it will be possible to create a stable framework of information within study reactions, comparing these background data to similar stimuli by people with specific disabilities. Otherwise, the risk of lack of reliability of records, may confuse the perceptions based on experience and knowledge of people (which is expected to have common variations among all participants) with those one arising from cognitive or sensory deficits. The analysis of a feeling perceptions as the "aesthetic pleasure", it is well suited to identify a set of primordial elements that can be tested and stimulated even in subjects with different abilities. The research knowledge, both in term of technical skills and upgrade in neuroscientific awareness, will be fundamental to proceed with a set of new research topics. These expected improvement (partly implemented in parallel with the second stage of NEVArt) include the sense of smell (i.e. product and environmental odours), the didactic field (teaching methodologies aware of vision and perception features), medical purposes, in particular improving some past research of the CIAS about the Parkinson's disease and some new studies about the communication with people with specific cognitive disorders, as Autism, in order to relate their emotional/physiological/cognitive response to different external stresses (starting from basic stimuli as colour, forms, lights, smell, etc.). Expected results also on the exhibit field, to provide suggestions on how to achieve the best way to display art works, enhancing the elements with the greatest impact on visitors. The environmental field, improving new methods to measure the subjective response of users to setting parameters (light, heat, cold, etc.) in order to combine the analysis of objective standards and on the field perceptions. In the safety topics, studying the impact of sensory data to verify the users' perceptions in emergency situations and how to take into account people awareness in emergency preparedness, especially with reference to wayfinding and to use of signs, lights and colours.

Keywords: neuroestethics, art, beauty, perceptions

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Policy Session supported by ProAct

Transferability of digital solutions for Integrated Care (ProAct qualitative research)

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Background: There is a need for stronger collaboration and integration of services between health and social care systems. Digital technology, which is a key driver of innovation in the care sector, presents an opportunity to address this challenge. Over the last decade, several digital platforms have been developed to support the delivery of integrated care in community settings. Nevertheless, few of them have been scaled up or moved beyond the geographical and/or service delivery context in which they have been developed, tested and initially deployed. On the contrary, most of the efforts done so far to develop technology for a more efficient integrated care have provided only ad hoc solutions, thus, limiting the impact and outreach of the innovations and leading to continuously reinventing the wheel. In addition, this transferability gap also prevents companies from exploiting and commercializing these solutions.
In order to shed light on the topic, a dedicated research is being conducted by AAATE, EASPD and AIAS in the framework of the ProACT project (http://proact2020.eu) funded by the European Commission under the Horizon 2020 framework. The referred research, so-called Transferability Study, aims at providing an explanatory model of the (positive and negative) factors which contribute to the transferability of digital platforms supporting integrated care. The Transferability model will provide key knowledge and essential insights for policy makers, service providers, end-user organizations and/or associations of professionals to become active drivers in the successful transfer of digital innovations supporting care, in general, and integrated care in particular.

Method: The methodology of the research is structured in three interconnected phases with a duration of two years. The phases cover: desk research, based on the analysis of the state-of-the-art and existing good practices (phase 1); qualitative research with relevant experts working on the field, in particular those with experience in implementing or scaling up digital solutions in integrated care settings (phase 2); and a final phase which applies the Delphi methodology to validate the conclusions elaborated in the previous phases, by involving a wide community of stakeholders (phase 3).

Key results: An overview of the results of the second phase of the above-mentioned transferability study will be presented, based on the implementation of semi-structured interviews following a qualitative research design. The study involved 20 experts from 13 different European countries, including several Eastern European countries, invited to participate due to their knowledge on the implementation of health and social care digital solutions and/or their experience in transferring integrated care technologies and practices.

Conclusion: Among the conclusions of the interview analysis, there are relevant insights about the key factors involved, which vary from organisational and structural barriers to instrumental, attitudinal or cultural facilitators influencing the transferability of the digital solutions. These responses were coded according to the Consolidated Framework for Implementation Research (CFIR). The experts also refer to the need of standardization in integrated care as a driver for transferability. These results are a first attempt to provide a deeper and systematized understanding of the barriers and facilitators to transfer digital solutions

Keywords: Transferability, Digital solutions, Integrated care, CFIR.

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Tweetable abstract: Key drivers and barriers to transfer digital solutions for integrated care. Qualitative research. CFIR. ProAct case study

Technology and Disability 31 (2019) S207–S222
IOS Press

Author Index Volume 31, Supplement 1

ISSN 1055-4181/19/$35.00