Editorial for Advances in Human-Centred Dementia Technology

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Introduction

It is estimated that 55 million people are living with dementia worldwide in 2021, and the numbers are expected to rise to 78 million in 2030 and 139 million in 2050 (Siriaraya et al., 2022; World Health Organisation, 2022). Dementia is an umbrella term that describes neurodegenerative disorders that impact memory, cognition, language, and behaviour (Beck et al., 1998; Cohen-Mansfield, 2001; Kane, 2001). Along with symptoms of dementia such as forgetfulness, disorientation and communication, People with Dementia (PwD) often lose their sense of autonomy and capacity to make decisions in various or all aspects of their life (Garcia-Palacios et al., 2002; Jones et al., 2015).

Currently, there is no cure for dementia. Thus, promoting well-being in PwD or Quality of Life (QoL) is considered a quintessential measure of effective dementia care (Van Nieuwenhuizen and Nijman, 2009). QoL for dementia care is multifaceted, which includes measures related to i. physical comfort, hygiene, and wellbeing, ii. safety, security, and order, iii. maintaining a sense of autonomy, dignity, and privacy, as well as iv. living a meaningful life, individuality, maintaining relationships, and enjoyment (Kane, 2001). However, such measures of QoL can be challenging to achieve due to the complexity of dementia symptoms (i.e. cognitive decline, losing the ability to communicate, behaviour that challenges, etc.) (Hennelly et al., 2021) and families' burden of caring for PwD against other competing priorities (Sury et al., 2013). In the case of institutionalised care, care settings suffer from understaffing and a low retention rate (Brown Wilson, 2009; Bunn et al., 2020), which leads care settings to focus on delivering everyday care (i.e. physical safety, assistance in eating and bathing) over other psychosocial QoL measures (Hicks et al., 2022). As such, there is an immense need to develop tools, interventions, and solutions to preserve and promote PwD's QoL and overall physical, emotional and mental well-being.

In the past few decades, substantial research within the HCI domain has investigated technology-supported healthcare and well-being interventions to cater to an array of cognitive, emotional and mental disorders such as body image and eating disorders (Matsangidou et al., 2020; Wiederhold et al., 2016), depression and anxiety disorders (Falconer et al., 2016; Griffiths et al., 2022; Otkhmezuri et al., 2019; Siriaraya et al., 2021), addiction (Intarasirisawat et al., 2020; Siriaraya et al., 2021, 2018), and prolonged grief disorder (She et al., 2022, 2021). Other HCI research has also investigated the use of technologies to promote positive health and well-being, including interventions for supporting and enhancing physical exercise (Kiriu et al., 2019; Matsangidou et al., 2017b, 2017a), elevating mood (Gaggioli et al., 2019; Lee et al., 2021; Peters et al., 2018), assisting in the pursuit of everyday happiness (Panote Siriaraya et al., 2022; Suzuki et al., 2021), and promoting pro-social behaviour and interaction (Ibrahim and Ang, 2018; Oliveira et al., 2021; Siriaraya et al., 2014, 2013; Slattery et al., 2021).

Given the wealth of literature on human-centred healthcare technology, we believe that utilising such technology to support PwD's lived journey through dementia holds great potential and benefits. However, such technologies need to attend to the unique design requirements when designing user-friendly and effective interventions for PwD. For instance, the fluctuation of cognitive impairment is a marked deficit of a dementia diagnosis. As such, PwD experience barriers in using mainstream web platforms due to difficulties in recognising the correct navigational path, have less eye/hand coordination when using input devices (i.e. mouse) and have a lower threshold for information overload (Slatin and Rush, 2003). Such cognitive deficits have also been reported to affect navigation and socialisation in 3D spaces (Siriaraya and Ang, 2019, 2012). Furthermore,

PwD face difficulties in maintaining attention and struggle to deactivate irrelevant stimuli (Cohen-Mansfield, 2001), which may affect the efficacy of technology-based interventions. It has also been reported in the literature that PwD are sometimes reluctant to participate in activities, interventions or use new technologies, due to their concerns about how other people view them, especially if they carry out some tasks or use technologies incorrectly (Nolan et al., 2006). Hence, it is a challenge not only to persuade PwD to join an activity but also to let their guard down and be truly engaged. Finally, difficulties in the areas of language and communication is a common symptom in PwD; it can be challenging for PwD to share their thoughts or express their emotions (Banovic et al., 2018). As such, it is imperative that tools, solutions, interventions, and technologies developed are based on sound human-centred principles, and sensitive to the needs of this population in a bid to design more user-friendly, highly engaging, and effective solutions (Tabbaa et al., 2020), which can also help PwD and those around them understand their emotions through means beyond verbal communication (Jiang et al., 2022a, 2022c; Tabbaa et al., 2021; Zeng et al., 2020a, 2020b).

In the following sections, we discuss key areas of digital technologies which are relevant to dementia care. We then conclude by summarising the six papers of this special issue.

Cognitive Assessment, Training & Remeniscence

Designing and developing interventions to detect and assess cognitive deficits is one area of research that has received significant interest within the HCI community. Research has shown that older adults with mild cognitive impairment are at higher risk of progressing to more severe cognitive impairment (Petersen et al., 2001) and that early detection of subtle signs of cognitive decline provides a greater opportunity for timely intervention (Dubois et al., 2015). In one study, researchers have utilised built-in sensors of smartphones to assess cognitive functions through user's gameplay performance and concluded that game-related metrics using off-the-shelf games could assess the quality and level of various cognitive functions including visuospatial function, visual search capability, mental flexibility, memory and attention (Intarasirisawat et al., 2019). Other studies have utilised Virtual Reality (VR) to detect cognitive skills that tend to degenerate as a result of dementia, such as spatial navigational deficits (Zakzanis et al., 2009). Other studies have explored the digitisation of existing traditional neuropsychological tests. For instance, Prange et. al (2021) utilised digital pens to provide better insight into the cognitive assessment results compared to the pen-and-paper version of a well-known cognitive performance test (The Trail Making Test) by offering measures that are very difficult or impossible to evaluate manually.

Other assessment interventions in dementia care include ones that aim to maintain and enhance QoL through training skills that tend to decline due to the diagnosis of dementia. In this context, studies have demonstrated the potential of technologies as a cognitive training tool to enhance spatial navigation skills (Cushman et al., 2008; White and Moussavi, 2016), cognitive control (Anguera et al., 2013; Mendez et al., 2015), memory training (Optale et al., 2010), cooking activities (Manera et al., 2015), and relearning everyday activities (Yamaguchi et al., 2012).

Reminiscence therapy is a popular psychosocial intervention in dementia care; it assumes that memory remains intact until the later stages of dementia and may be used to communicate with PwD (Siriaraya and Ang, 2017). To aid reminiscence therapy, libraries of stimulus (i.e. old pictures) are used to trigger memories and stimulate relevant and meaningful conversation between PwD and caregivers (Jiang et al., 2021). As such, research within the HCI community has investigated presenting stimulus using various technologies such as smartphone Apps (Ekström et al., 2017), projectors or large displays (Sas et al., 2020; Siriaraya and Ang, 2014), head-mounted VR (Afifi et al., 2022, 2021; Hodge et al., 2018; Moyle et al., 2018; Rose et al., 2019a; Tabbaa et al., 2019), and

interactive intelligent interfaces (i.e. interactive pillow) (Houben et al., 2020), using a variety of interaction modes such as watching (Sas et al., 2020), head movement (Hodge et al., 2018; Moyle et al., 2018; Rose et al., 2019a; Tabbaa et al., 2019) to the use of touch (Houben et al., 2020), and gesture-based interactions (Siriaraya and Ang, 2014). Using a variety of novel technologies, researchers stimulated recollections of autobiographical memory and conveyed familiarity with a given scene, which is an essential requirement for reminiscence therapy (Afifi et al., 2022, 2021). Studies have shown that the use of novel technologies for reminiscence therapy is more effective than traditional methods (Hayhurst, 2018). More recently, novel research has started to look into recognising emotional elicitation in older adults during reminiscence therapy using physiological signals; aiming to provide in-depth insights beyond PwDs' verbal feedback, which could lend a lens to therapy administers especially for PwD who face barriers with verbal communication (Jiang et al., 2022b, 2022d).

Promote Positive Well-being

Beyond diagnosis and assessment, many studies have focused on designing technology-based interventions to promote positive well-being and mood. One major factor leading to compromised QoL is the significant barriers PwD face in accessing stimulating, interesting and engaging experiences beyond their physical premises due to location, weather, safety concerns or mobility constraints. As such, many studies have examined how technologies can be designed to promote positive well-being. In one study, researchers iteratively co-designed a tangible virtual garden system with PwD to practice gardening; a common hobby PwD enjoyed but could no longer engage in such a physically draining hobby or no longer have access to gardening spaces (Siriaraya and Ang, 2017). VR has also been used to "bring the outside in", showing that 360-Degree Video-Based Environments can "take" PwD to locations and experiences that are otherwise difficult to reach (Rose et al., 2019a; Tabbaa et al., 2019). Such research concluded that VR is an effective therapeutic tool to promote the positive well-being of PwD who are in their early stages of dementia (Hodge et al., 2018; Moyle et al., 2018; Siriaraya and Ang, 2014) as well as those who are on the moderate to the severe spectrum of the diagnosis, highlighting the potential of VR to reduce behaviours that challenge through "teleporting" PwD who are presenting with behaviours that challenge to a low stimulus world and isolating them from the physical world, which may have contained elements that have triggered their aggressive behaviour in the first place (Rose et al., 2019b; Tabbaa et al., 2019).

Socialisation & Meaningful Conversations

The body of research has concluded that the use of technologies to build strong and meaningful connections between PwD and their social circles (i.e. family, friends, caregivers, the community, etc.) and engaging them in social activities can reduce the speed of the cognitive decline and depressive symptoms (Barbosa Neves et al., 2019; Kleinberger et al., 2019; Ramírez et al., 2014). However, family members often struggle to find topics to discuss with PwD because they are unsure if PwD will be interested or engaged in the topic or whether they would even remember the people, stories, or events related to the topic itself (Muñoz et al., 2021). Research in the HCI community has investigated the design and deployment of various interventions to create "better visits" (i.e. more fun, engaging and enriched) for family members visiting PwD in their care setting. Such research explored the use of social media applications to collate content (i.e. pictures, videos, articles, etc.) and then use them during visits as discussion prompts (Welsh et al., 2018). Others have designed a "Living Moments" system where family members can send digital messages delivered digitally as well as printed postcards to PwD, where in return, PwD can respond to their family members using the system (Thoolen et al., 2022). Finally, one study examined tablet-based games for PwD and family members to engage with during visitation (Muñoz et al., 2021).

In efforts to further promote social interactions amongst PwD, the body of research has also looked into Socially Assistive Robots (SARs) in the context of dementia care (Lu et al., 2021). Perhaps one of the most popular social robots is PARO; a robotic seal that has been designed explicitly for PwD (Wada et al., 2008; Wada and Shibata, 2008). PARO has been used in a variety of care settings, such as day-care centres (Yu et al., 2015), nursing homes (Jøranson et al., 2015), long-term care facilities (Petersen et al., 2016) and hospital settings (Hung et al., 2021).PARO behaves like a domestic pet and responds to touch, light, sound, motion, and temperature. Artificial Intelligence (AI) and machine learning programmed within PARO enables it to recognise and respond to the social and emotional prompts of those who interact with it. The body of research has found PARO to be an effective social companion, describing it as "like a buddy" (Hung et al., 2021). Furthermore, research has found that PARO enhanced conversations between caregivers and PwD, promoting more smiles and laughter in conversations (Jøranson et al., 2015). Other benefits have been reported in the body of literature that supports the use of SARs in dementia care; SARs can decrease stress and anxiety (Petersen et al., 2016) and promote playfulness amongst PwD (Marchetti et al., 2022).

Exergames

Physical exercise is important for PwD as it improves their physical fitness and contributes to a better QoL (Barnes, 2015). However, many PwD lose interest in themselves and others and lack the motivation to engage in activities (Kitching, 2015). Furthermore, PwD struggle to focus attention during exercise and deactivate irrelevant stimuli (Schutzer, 2004). As such, several research works have designed interventions to motivate physical exercise through gaming technologies or what is known as exergames. Studies have utilised a range of technologies to promote physical exercise, including VR (Eisapour et al., 2020; Muñoz et al., 2022; Rings et al., 2020), mobile applications (Barisch-Fritz et al., 2022) and gaming consoles (Liao et al., 2022). Many studies have highlighted the benefits of using exergames to promote physical exercise amongst PwD, including increased motivation to exercise regularly, or that exergames, unlike traditional exercising, sessions do not feel burdensome (Eisapour et al., 2018), individualised and tailored exercises to PwDs' capabilities helps PwD feel capable and motivated (Barisch-Fritz et al., 2022).

Accessibility & Independence

PwD life, identity and personhood are not defined by their dementia diagnosis. As such, creating a positive narrative around "life with dementia" is essential to help PwD maintain their independence, autonomy, individuality, and, ultimately QoL for as long as possible (Yates et al., 2019). As such, many researchers have investigated ways in which PwD, especially those in their early stages of dementia, can enjoy life more independently. For instance, one study examined the accessibility requirements to enable PwD to independently search health information online (Dixon et al., 2022). Other studies examined different ways to provide instructions and reminders about daily activities, including talking alarm clocks to provide reminders and step-by-step auditory instructions and provide encouragement (Lancioni et al., 2017, 2018) and embodied conversational agents that offer reminders, attention to important tasks or events, as well as image and video displays for task-oriented interactions (Wargnier et al., 2018). Several studies focused on providing assistive technologies to support PwD and their caregivers with everyday activities (Guan et al., 2021), such as help wearing clothes independently using Radio-Frequency Identification (RFID) tags on clothes and motion-tracking technology (Mahoney et al., 2014). To help and motivate PwD to visit accessible and dementia-friendly places, one study developed a mobile application which PwD can use to identify dementia-friendly public places (i.e. parks, cafes, shops) based on information provided and PwD rating (Dixon et al., 2022).

Preserving the physical safety of PwD is a quintessential measure of QoL (Kane, 2001). As such, extensive research efforts were made to investigate technologies that can support the physical safety of PwD. One study features a sensor-based technology kit that is specifically designed for PwD who live independently. The kit included home-leaving sensors, smoke and water leak sensors, motion-based bed sensors and motion-based light sensors. These sensors can be set to communicate with up to six family members via text messaging and phone calls (Malmgren Fänge et al., 2020). Several studies also designed interventions to support way-finding and navigation. One study designed a GPS-based application where PwD can speak to the app using voice command to input the destination, to which, the app would provide navigation assistance in the modality and pace suitable for PwD (Kwan et al., 2020). Wandering is also another area related to maintaining the physical safety of PwD, and it is one worrisome behaviour that PwD exhibit, and it increases the burden on family caregivers to keep PwD from getting lost (Megges et al., 2017a). As such, location tracking, including outdoor tracking (Faucounau et al., 2009; Megges et al., 2017b), indoor areas (Ng and Kong, 2016), and parameter setting (where caregivers or family members receive notifications if PwD wanders beyond a pre-defined parameter) (Olsson et al., 2013), has shown to provide an effective solution to PwDs' wandering, getting lost and not finding their way back. Such technology can enable some PwD to have greater freedom and independence and can ultimately reduce the use of unpleasant solutions such as pharmacological interventions and physical restraint (Alzheimer's Society, 2015).

Summary of the Special Issue

It would be impossible to cover such a breadth of application areas of technology in dementia care within the scope of the special issue. We have received a significant number of submissions, and ultimately, we accepted six papers covering two key technology fields which are starting to make an important impact in healthcare generally, and dementia care more specifically: i) machine learning and ii) immersive technology.

The paper "Exploiting linguistic information from Nepali transcripts for early detection of Alzheimer's disease using natural language processing and machine learning techniques" (Adhikari et al., 2022) demonstrated an important application area of machine learning on linguistic data, especially on non-English and low-resource language. It highlighted the importance of designing equitable technology, which is accessible, especially to the most vulnerable people and communities. The paper "Understanding Predictive Factors of Dementia for Older Adults: A Machine Learning Approach for Modeling Dementia Influencers" (Chien et al., 2022) looked at how machine learning techniques can be used to understand what demographic, physiological and psychosocial factors are predictive of dementia status. This paper presented a case of using advanced technology to help better understand dementia using large, complex and multi-faceted datasets.

The three papers, "'Bring me sunshine, bring me (physical) strength: The case of dementia. Designing and implementing a virtual reality system for physical training during the COVID-19 pandemic" (Matsangidou et al., 2022), "The cupboard task: An immersive virtual reality-based system for everyday memory assessment" (Varela-Aldás et al., 2022) and "Effects of Incorporating Virtual Reality Training Intervention into Health Care on Cognitive Function and Wellbeing in Older Adults with Cognitive Impairment: A Randomized Controlled Trial" (x) presented an interesting case for using VR to support physical and cognitive health of people with dementia. These papers showed that digital interventions based on emerging technology such as VR can provide an alternative to help improve the quality of life of PwD. Finally, the paper "Augmented assistive technology: the importance of tailoring technology solutions for people living with dementia at

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home" called for a human-centred approach to designing and deploying AR technology to support everyday activities.

In conclusion, we hope that this special issue has presented a case for more future research in designing, deploying and evaluating emerging technology to support dementia care, in a human-centred manner.

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