SYNCHRONICITY

Exploring the Impact of Socio-Technical Interventions on Social Isolation

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Abstract

This research project explores the impact of Human-Computer Interaction (HCI) and Information and Communications Technology (ICT) based designs on social isolation experiences, focusing on **synchronous coordination** and **asynchronous collaboration**. It investigates the experiences, engagement patterns, and preferences of a broad range of participants facing social isolation and assesses how HCI-based interventions affect the frequency and quality of social engagements. The study consists of **co-design workshops** and **prototype testing** phases, gathering insights into isolation challenges, and proposing effective **socio-technical interventions**.

The results of this study contribute to the field of HCI by highlighting the potential of socio-technical interventions to alleviate social isolation and improve well-being. By examining a diverse range of individuals, the research informs the design of interventions applicable to a broader audience. Additionally, the study considers how other factors can impact the dynamics of social isolation interventions, with **introversion** vs. **extroversion** being specifically recognised.

This project aspires to generate innovative ideas and technological designs that support individuals suffering from isolation, promoting social well-being, and enhancing social support networks. By addressing the challenges of social isolation through HCI interventions, this research has the potential to reach a wide range of affected individuals, regardless of the underlying cause of their social isolation.

Keywords: social isolation, HCI, synchronous design, asynchronous design, co-design, introversion, extroversion, socio-technical interventions, social support.

Acronyms

AI	Artificial Intelligence
APK	Android Package Kit
AR	Augmented Reality
CELSS	Controlled Ecological Life-Support System
CEMS	Computing, Engineering and Mathematical Sciences
HCI	Human Computer Interaction
ICT	Information and Communications Technology
VR	Virtual Reality

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Fig x.x	Reference to an image or figure.

Acknowledgments

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Chapter 1. Introduction

This research project explored the intricate nature of social isolation, focusing on the experiences of individuals, identifying contributing factors, and examining the tools employed to counteract this complex phenomenon. The ultimate goal was to inform the development of effective interventions and support systems based on HCI to mitigate the adverse effects of social isolation. These HCI and ICT-based social intervention tools are commonly referred to throughout this thesis as 'socio-technical' interventions. This introductory section outlines the origins of this study, elucidating the research's purpose and significance, acknowledging limitations, and framing the investigation with a set of research questions. An outline of the thesis structure is shown in **Fig 1.1**.

1.1 Thesis Structure

Chapter 2: Literature Review

- A comprehensive review of existing research on the causes, consequences, and potential solutions for loneliness and social isolation.
- A focus on recent studies conducted during the COVID-19 pandemic.
- An exploration of interventions, including benefits, limitations, and recommendations.
- Additional research based on feedback from co-design workshops, examining the interaction between introversion, extroversion, and social isolation.

Chapter 3: Co-design Workshops

- Details the methodology employed during co-design research workshops.
- An analysis of data collected from workshops and individual interviews.
- Insights into how these findings influenced intervention design concepts.

Chapter 4: Catalogue of Intervention Concepts

- Presentation of refined intervention concepts derived from the co-design workshops.
- Selection and development of synchronous and asynchronous design prototypes.

Chapter 5: Design Prototypes

- Methodology and procedures for prototype testing.
- Analysis of data collected during testing.
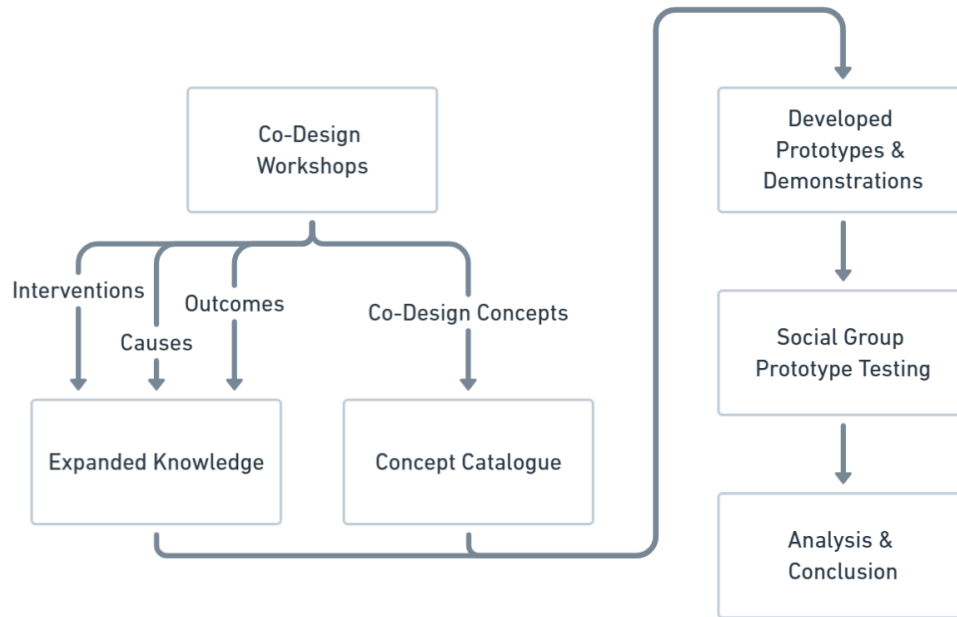
Fig 1.1 - Diagram showing the flow of this research project.

Chapter 6: Informed Design

- Providing refinements and recommendations for future iterations of the tested design prototypes based on user testing feedback and research insights.

Chapter 7: Discussion

- Analysis of data collected from co-design workshops and prototype testing.

- Research implications, and reflections on strengths and limitations.

- Insights into potential avenues for future research.

Chapter 8: Concluding Thoughts

- Revisiting and discussing the research questions.

- Summary and concluding thoughts.

1.2 Personal Experience

The COVID-19 pandemic, and subsequent quarantines and lockdowns, were a particularly unusual experience for me. But perhaps not in the way people who know me personally would have expected.

Due to personal reasons, my daily life was characterised by a pattern of avoiding close contact with people, particularly those who showed signs of illness. The frequent use of antiseptic wipes, sanitising my hands when leaving stores, and even wiping down my work

desk and computer were all common behaviours. Though essential for my mental well-being at the time, these behaviours often led to feelings of isolation. This was all before the pandemic occurred.

My introverted nature compounded the challenges of socialising, with most of my interactions occurring at work. Outside of work, I was often too fatigued for in-person social activities. I was open to remote interactions through digital platforms, such as online gaming, but these interactions were not particularly regular before the pandemic.

When the pandemic hit and social distancing became the norm, it led to significant societal changes. The pandemic necessitated a shift in how people interacted socially, resulting in increased usage of online conferencing. In-person gatherings became unfeasible, giving rise to alternatives like group chats and regular video meetings. For many, these changes were disorienting and challenging, but for me, it was Tuesday. In fact, my level of social activity increased, a trend that continued through much of 2020 and 2021.

My extensive reading during this project led me to understand the numerous ways people commonly communicate and socially interact. My social interactions were heavily biassed in favour of delayed interactions - described as 'asynchronous' throughout this research project - such as messages left on chat apps. Real-time communication - described as 'synchronous' in this project - such as video chats or in-person conversations were a relatively rare occurrence.

For my purposes, finding a way to increase my synchronous social activity, or promoting additional asynchronous activities, would both be of personal benefit. This fuelled my study into isolation interventions from a broader perspective, with research simultaneously serving academic goals and personal improvement - a unique blend of motivation for this project.

1.3 The Purpose and Significance of this Project

This research project was driven by an investigation into the potential of HCI-based interventions to mitigate the impact of social isolation experienced by a diverse range of individuals. By exploring the experiences, engagement patterns, and preferences of

participants, the study aimed to identify effective design elements capable of addressing the challenges posed by social isolation. The primary focus was on the exploration of the influence that socio-technical designs can have on the frequency and quality of social interactions, with the intent of reducing loneliness and improving general well-being. The hypothesis was that socio-technical interventions have the potential to benefit a broad spectrum of individuals affected by social isolation, regardless of the cause of that isolation. However, this benefit may be influenced by personal preferences or traits, a factor that requires additional study.

This study aimed to explore the reported causations and challenges voiced by individuals who have experienced social isolation. Moreover, it delved into the subjective significance individuals attach to these challenges, and solicited insights from participants regarding potential technological solutions to counter social isolation. The analysis of these proposed ideas aimed to uncover recurrent themes and underlying needs, which, in turn, could provide valuable guidance for the development of innovative HCI designs.

By examining the experiences of individuals when engaging with HCI designs, this research sought to pinpoint design elements that could effectively cater to the distinct needs of a broad range of demographics. Through a deep analysis of engagement behaviours, satisfaction levels, and preferences, this investigation aimed to inform the future creation of HCI interventions that holistically address the spectrum of social isolation experiences.

1.4 Scope

The scope of this research is defined by the objectives and boundaries that guided the investigation into the impact of socio-technical interventions on mitigating social isolation.

1. **Exploration of Social Isolation:** This study focused on understanding the experiences of individuals who have faced social isolation from a variety of causes. It aimed to investigate the unique challenges and opportunities for addressing isolation arising from a broad array of sources, including economic, medical, and geographic factors, rather than focusing on a single narrow subsection of the population.

2. **Development and Testing of Socio-Technical Interventions:** The study involved the design, implementation, and testing of prototype socio-technical interventions aimed at reducing social isolation. These interventions were intended to provide social encouragement, enhance social engagement, promote connectedness, and mitigate the negative effects of long-term isolation.

3. **Broad Intervention Efficacy:** This research explored how a range of demographic and personality types may influence the effectiveness of HCI interventions. It investigated how individuals respond differently to the interventions, and whether this response is influenced by certain inherent design, or personal, characteristics.

However, certain aspects are beyond the scope of this research:

1. **Global Cross-Cultural Comparison:** While acknowledging the importance of cultural variations, this study's participant pool was limited to individuals from the United Kingdom. Therefore, the findings might not fully represent the diversity of experiences across different countries, regions, and demographics.

2. **In-Person Interaction Dynamics:** This research primarily relied upon online interactions and communication tools due to health-related limitations. Consequently, the nuances of face-to-face interaction dynamics were not extensively explored.

3. **Comparative Analysis of Traditional Interventions:** A comprehensive direct comparison between socio-technical interventions and traditional social engagement methods was beyond the scope of this research.

4. **In-Depth Examination of Non-Participant Perspectives:** The study primarily focused on participant insights and experiences and does not extensively explore perspectives from individuals who did not directly participate in the research.

The research's findings and conclusions are situated within this defined scope, acknowledging both the contributions and areas where future research could expand.

1.5 Research Questions

This research project sought to gain deeper insight into the experiences of individuals facing social isolation and explore the potential impact of different socio-technical designs on their social experiences. The goal was to develop socio-technical design concepts that enhance both the quantity and quality of social interactions for those experiencing social isolation.

Evolution of Research Questions

During the co-design workshops, the importance of comparing synchronous and asynchronous HCI designs for intervention development became evident due to their distinct characteristics and potential impact on social interaction. Synchronous designs mimic real-time face-to-face interactions, while asynchronous designs provide flexibility in engagement timing. Evaluating the situational effects of these designs on participants offered insights for tailoring interventions to specific preferences and circumstances, leading to more effective methods of addressing social isolation. Through a comprehensive analysis of engagement, satisfaction, and design preferences, the study strived to contribute to the development of more effective socio-technical interventions that cater to the diverse needs of individuals and groups experiencing social isolation.

While universally effective solutions are desirable, this study recognised the significance of tailoring interventions to address specific causes of isolation, whether they are synchronous or asynchronous in nature. Moreover, it explored additional factors that could impact intervention effectiveness, ultimately aiming to yield more targeted and beneficial outcomes.

1.5.1 Initial Research Questions

1. What causes and outcomes related to social isolation are recognised as significant for intervention development by a selected population group?
2. What are the existing weaknesses or gaps in social isolation interventions, and how can HCI-based designs fill these gaps to better support individuals?

3. What factors may impact the effectiveness of socio-technical interventions, and how do these factors affect the preferences of users?

4. What socio-technical solutions can be employed to mitigate the impact of social isolation among a wide demographic of sufferers?

These research questions were kept at the forefront during the co-design workshop component of the thesis, the results of which were then utilised to expand these questions - specifically question 4 - and guide the production and analysis of socio-technical prototypes.

1.5.2 Research Questions: Expanded

The co-design workshops undertaken as part of this research project unveiled a multitude of causes and potential solutions related to social isolation, revealing an important categorisation which divided design development into two groups: **synchronous** and **asynchronous** interactions. Building on these insights, the research questions were expanded to explore the impact of synchronous and asynchronous designs on addressing social isolation needs. The workshops also recognised that certain factors, specifically introversion and extroversion, may have an impact on intervention preferences. This was kept in mind during prototype testing, to further assess what effect it may have.

Expanded Research Questions:

5. To what extent do participants engage with and benefit from socio-technical interventions for social isolation?

6. How do synchronous and asynchronous HCI designs compare in terms of their effectiveness in improving the frequency and quality of social engagement?

7. Which design elements of the socio-technical interventions are effective in addressing the social isolation needs of individuals?

Chapter 2. Literature Review

Social isolation and loneliness are complex issues influenced by numerous factors, with physical, mental, and emotional aspects. To explore these phenomena and their potential solutions effectively, it is essential to establish a solid foundation through a comprehensive literature review. This review not only provides insight into the causes and consequences of social isolation but also informs the subsequent data gathering and analysis conducted during the co-design workshops and prototype development phases of this study.

2.1 The Evolution of Focus

The inception of this research project initially revolved around the examination of confined habitation scenarios, particularly within space stations and hypothetical extraterrestrial habitats. The intent was to address the psychological and social challenges associated with long-term confinement in these extreme environments, necessitating innovative solutions while adhering to size and mass constraints. However, as the exploration of confined habitation scenarios progressed, it became evident that the complexity of this research surpassed the feasibility of this project. Reproducing and empirically evaluating proposed HCI designs within these extreme habitats posed insurmountable challenges.

As a result, a strategic shift in research focus was necessary. Extensive research on confinement and isolation, such as Mars habitat simulations and studies at Concordia Station in Antarctica, revealed a common thread - social isolation (Pagel and Choukèr, 2016). These studies documented a range of physiological and psychological effects resulting from long-term confinement, including behavioural changes, cognitive impairment, and physiological alterations (Gemignani *et al.*, 2014; Pagel and Choukèr, 2016).

The 180-day Chinese Controlled Ecological Life-Support System (CELSS) experiment in 2019 expanded on these findings, highlighting the variability in how individuals responded to isolation (Yuan *et al.*, 2019). Factors such as prior experience, personality traits, and genetic predisposition played crucial roles in these variations.

It became clear that social isolation was a pervasive concern in the context of hypothetical space habitats, demanding further investigation. Consequently, the research trajectory of this project shifted from the broader challenges of confined extraterrestrial habitation to a focused examination of social isolation and its potential mitigation through HCI-based tools. This transition was motivated by the practicality and relevance of addressing social isolation, a well-documented issue in the context of space habitation, while still considering potential applications in contemporary non-terrestrial environments.

In summary, the research trajectory intentionally evolved from a broad exploration of confined habitation solutions to a focused investigation into the ramifications of social isolation and the potential of HCI-based tools to address these challenges.

2.2 A Global Pandemic - Highlighting an Issue

The COVID-19 pandemic in 2020 brought the issues of loneliness and social isolation to the forefront of public awareness. Widespread quarantines and lockdowns enforced isolation for a substantial portion of the global population, leading to significant increases in mental health disorders like anxiety, depression, and obsessive-compulsive disorder (Robb *et al.*, 2020). The unique circumstances presented by the pandemic offered an unprecedented opportunity to study social isolation on a massive scale, with legitimate concerns arising about its detrimental effects on individuals' well-being (Hwang *et al.*, 2020).

Robb et al. (2022) conducted extensive research during this time, shedding light on the potential negative consequences of prolonged isolation, particularly for vulnerable groups. These vulnerable categories included the elderly, individuals in insecure jobs, those with low incomes, and those living in overcrowded housing. Additionally, marginalised communities, including minority ethnic groups, migrants, refugees, and women and children in abusive households were identified as at-risk groups. (Blumenshine *et al.*, 2008; Kantamneni, 2020).

Previous studies of epidemic and pandemic events have highlighted disparities in exposure, susceptibility, and treatment for these disadvantaged groups, leading to increased stress on already vulnerable populations (Blumenshine *et al.*, 2008). Notably, these marginalised

factors often cluster within specific communities, where individuals suffering from one disadvantaged condition frequently share multiple limitations or disadvantages within their social circles (Gayer-Anderson, Latham and El Zerbi, 2020).

However, it's important to recognise that the issues of social isolation extend beyond these vulnerable groups. A study among the general population in Nepal in 2020 found that between 23% and 34% of participants reported experiencing some combination of depression and anxiety symptoms as a result of pandemic lockdowns (Sigdel *et al.*, 2020).To illustrate this further, studies have highlighted that both vulnerable and non-vulnerable age groups can be at risk for adverse mental health effects during such events (Perrin *et al.*, 2009). Research also reveals that the middle-aged worker population (ages 31-65) experienced a heightened incidence of mental health comorbidities during lockdowns, potentially due to increased daily responsibilities and pressures (Perrin *et al.*, 2009).

2.3 Signs and Symptoms

During the COVID-19 pandemic, mandated restrictions on gatherings and social distancing guidelines resulted in a significant reduction in social interaction and activity for many individuals. This reduction led to increased loneliness and a higher risk of mental and emotional afflictions (Benke *et al.*, 2020). These studies examined the effects of social isolation across various social, cultural, and physical demographics, finding greater reductions in social contact and increases in psychopathological symptoms and mental health impairments across all groups (Grover *et al.*, 2020; Sigdel *et al.*, 2020).

The predominant issues identified during these studies were depression, anxiety, and comorbidity of depression and anxiety. These factors were central to many studies on social isolation during the pandemic. Additionally, research has linked behavioural and emotional issues to long-term isolation and loneliness, including neuroticism, perceptions of stress, substance abuse, and even factors such as accommodation selection and anthropomorphising animals and objects (Schnittger *et al.*, 2012).

Beyond the context of the COVID-19 pandemic, loneliness has been studied as a possible causal link for several comorbidities. Psychological conditions with causal or reciprocal links to isolation and loneliness include depression, alcoholism, stress, anxiety, suicidal thoughts, and cognitive impairments like Alzheimer's disease (Mushtaq, 2014).

The impact of loneliness extends beyond mental health, significantly affecting physical well-being. Social isolation and loneliness have been linked to elevated levels of specific protein markers associated with coronary heart disease, even in socially isolated individuals with no prior risk factors or medical history of heart disease (Heffner *et al.*, 2011). In terms of overall physical health and all-cause mortality, social isolation and loneliness impair quality of life and well-being, with social isolation being significantly associated with mortality. Common physical health risks linked to social isolation include cardiovascular disease, cognitive decline, hypertension, heightened inflammatory and metabolic responses to external stressors, and associated complications and comorbidities (Steptoe *et al.*, 2013).

2.4 Social Isolation - Everyday Problems

While the COVID-19 pandemic may have made social isolation a national issue, it isn't limited to the pandemic's unique circumstances. It affects a wide variety of demographics, including the elderly, impoverished, and chronically ill. In 'Social Isolation in Modern Society,' Hortulanus et al. (2006) suggest that isolated individuals might be a lot more common than previously thought:

> *"Dramatic examples of socially isolated people raise the question of whether we are dealing with a small group of dropouts from society or with the tip of an iceberg - for the rest a fairly invisible one."*
> - 'Social Isolation in Modern Society,' Hortulanus et al., (2006).

Beyond the context of the COVID-19 pandemic, numerous common sources of social isolation have been identified. Ageing is among the most prevalent, with older adults and the elderly being particularly vulnerable (Cornwell and Waite, 2009; Schnittger *et al.*, 2012; Robb *et al.*, 2020). Several factors contribute to this vulnerability:

- Reduction in Social Network Size: Bereavement often leads to a decrease in the size of an individual's social network.

- Inability to Socialise: Physical limitations such as injuries, impairments (e.g., vision or hearing loss), or disabilities can hinder social interaction.

Studies examining the impact of loneliness across the human lifespan have identified consistent patterns. A study in Germany (N=16130) revealed that loneliness and social isolation tend to peak in specific life stages (Luhmann and Hawkley, 2016):

- **Young Adults (Under 30)**: Loneliness often peaks during young adulthood.

- **Mid-Life (30-65)**: Loneliness gradually decreases during the working years.

- **Retirement Age (65+)**: Loneliness rises again, reaching another peak among those over 80 years old, consistent with earlier findings (Cornwell and Waite, 2009; Schnittger et al., 2012; Robb et al., 2020).

Luhmann and Hawkley (2016) also found that living alone was not a key risk factor for loneliness among younger age groups. Instead, lack of engagement with larger networks of family and friends played a more significant role. This did not hold for older participants, however, where living alone was a key risk factor contributing to isolation and loneliness. For younger age groups, same-sex social networks - particularly among adolescents experiencing rejection or segregation from peer groups - posed a greater risk of severe mental health issues in later life (Heinrich and Gullone, 2006; Zhang *et al.*, 2015). This comparison highlights how social needs and preferences can not only vary due to innate characteristics of an individual but can also develop over time due to age or circumstance.

Income levels, particularly for individuals aged 30-65, emerged as another risk factor for loneliness and isolation. While low or uncertain income posed a risk for this group, severe poverty or reduced socioeconomic status affected all age groups to some extent and could contribute significantly to isolation. The hypothesis suggests that workplace communities may play a crucial role in fostering and maintaining broader social networks, which have a beneficial effect on mental and emotional well-being (Luhmann and Hawkley, 2016).

2.5 Overcoming Social Isolation

Addressing social isolation and maintaining feelings of connectedness within communities is crucial, especially in situations like the COVID-19 pandemic. Hwang et al. (2020) categorised methods for overcoming social isolation into three broad areas:

- **Maintaining Basic Needs:** Ensuring access to necessities like food and medication, establishing daily routines, and engaging in physical and mental activities.

- **Managing Emotions and Psychiatric Symptoms:** Paying attention to psychological well-being; acknowledging and managing emotions and mood.

- **Keeping Connections:** Spending time with family/friends and maintaining connections with social support networks.

Various interventions are traditionally proposed to maintain connections when individuals are isolated from their usual social communities. Some interventions, such as one-to-one "befriending" programs where volunteers connect with socially isolated individuals, have been implemented but show mixed efficacy. While the use of social intervention tools is beneficial, several studies have shown that one-to-one interventions appear to have little to no significant effect (Findlay, 2003; Cattan, White and Bond, 2005).

On the other hand, interventions that have shown promise typically share the following characteristics (Cattan, White and Bond, 2005):

- **Group-Based:** They involve multiple participants.

- **Target Specific Groups:** They focus on specific demographics.

- **Specific Focus:** They emphasise activities such as educational training, creative pursuits, support activities, or physical activities.

Creative activities have demonstrated notable effectiveness in mitigating social isolation (Goncarlo *et al.*, 2021) - a study that argues the creative process, used in a social context, can be used to forge new relationships as well as strengthen existing social bonds.

It is worth noting that many studies, especially within the realm of HCI, tend to focus on elderly populations. Reedman-Flint et al.'s (2022) scoping review of loneliness and social

isolation found that a substantial portion of papers (over a third) concentrated solely on the elderly population, with limited attention to "edge communities" such as individuals with physical or mental conditions, remote workers, or impoverished communities (Reedman-Flint *et al.*, 2022). This observation aligns with the prevalence of social isolation intervention research targeting the elderly population - a randomised search for "social isolation interventions" produced a page of twenty-five results, of which twenty-two specifically targeted elderly populations. Research on contemporary solutions to social isolation are also limited due to a lack of evaluated interventions, varying participant pools, and assessed outcomes, with poor reporting and study quality also being significant issues in existing literature (Dickens *et al.*, 2011, p. 20; Reedman-Flint *et al.*, 2022).

2.6 New Technology for an Old Problem

While much of the existing research on social isolation interventions has been focused on the elderly population, these findings can serve as a foundation for broader applications. Studies examining the use of technology-based solutions for addressing social isolation, often referred to as "socio-technical interventions," offer valuable insights even when tested on limited demographics (Waycott *et al.*, 2015).

One such study evaluated the impact of technological interventions, including telephone calls, text messages, and emails, on loneliness and social isolation among elderly participants (Burholt *et al.*, 2020). The hypothesis was that these interventions could mitigate social isolation and loneliness, but that age might influence the effectiveness. Older participants (aged >75) might respond differently due to reduced familiarity with technology and altered expectations regarding social engagement through technology. The study's results demonstrated that technological interventions can help mitigate social isolation, but their impact on loneliness varied. Notably, older participants experienced less significant reductions in loneliness, suggesting that the effectiveness of these interventions hinge upon meeting older individuals' expectations for social contact (Burholt *et al.*, 2020, p. 10).

"Loneliness is influenced by norms and life-course experiences, and unless the quality and quantity of family contact provided by technology-mediated communications meets the expectations of older people, it will not be effectively reduced."

- Quote from 'Technology-Mediated Communication in Familial Relationships: Moderated-Mediation Models of Isolation and Loneliness', Burholt et al., 2020.

Future research recommendations from Burholt et al. (2020) emphasised tailoring interventions to target audiences' personal preferences and life experiences. Experience and familiarity with technology not only affects intervention effectiveness but also participation in technology-related activities. Studies have shown that people with limited familiarity with specific technological tools are less likely to use them, even when made available (Waycott *et al.*, 2016). While these studies often focused on elderly participants, the reasons for non-participation - such as tiredness, lack of time, and frustration with technology - can apply to a broader demographic.

Existing socio-technical interventions primarily revolve around social networking applications and touch-screen technologies, often aiming to make participants more proficient in using modern communication tools like video conferencing (Baker et al., 2018). Research in this domain has frequently targeted elderly populations, many of whom had limited experience with touch-screen interfaces. These studies explored whether increased text- and image-based communication through platforms like Facebook and Instagram could alleviate feelings of loneliness and isolation (Meta Platforms, Inc., 2023). However, a scoping study of existing research suggests a bias toward social networking and touch-screen technologies, highlighting a significant research gap in the use of emerging technologies or solutions that extend beyond the conventional social network paradigm of text chats and photo-sharing (Baker *et al.*, 2018).

2.7 Introversion & Isolation

When combined with other personality traits, such as emotional instability, introversion may heighten the risk of anxiety and depression (Michalos, 2014). In contrast, extroversion is characterised by sociability, assertiveness, excitability, and outgoing tendencies.

Extroversion is typically associated with increased happiness, although this relationship is complex, and "happy introverts" are not uncommon (Hills and Argyle, 2001).

Introversion has several associations with health issues also related to social isolation. It has been linked to an increased risk of cardiovascular problems like coronary arterial disease (Zaki, 2014) and a higher likelihood of poor nutritional metrics. Feelings of loneliness are also frequently reported by introverts, in line with an identified human need for social support (Duffy *et al.*, 2018; Card and Skakoon-Sparling, 2023). Research indicates that socialisation events can have significantly positive outcomes for both extroverted and highly introverted individuals (Duffy *et al.*, 2018). Several studies suggest that personality type plays a crucial role in predicting experiences of loneliness, with introversion strongly associated with feelings of isolation (Mund and Neyer, 2019; Buecker *et al.*, 2020; Card and Skakoon-Sparling, 2023). These findings challenge the idea that highly introverted individuals are inherently immune to the adverse effects of social isolation and loneliness.

A key factor in positive social outcomes appears to be the availability, whether actual or perceived, of social support. Extroverted individuals often have easier access to social support due to their willingness to seek assistance and guidance from others during challenging times, or because their larger social networks offer more opportunities for support (Swickert *et al.*, 2002). Thus, the challenge lies in identifying and facilitating supportive social connections, especially for introverted individuals.

Contrary to expectations, studies conducted during the COVID-19 pandemic suggest that introverted individuals adapted better to forced isolation scenarios, avoiding self-destructive behaviours and experiencing reduced mortality rates compared to extroverted individuals in similar situations (Glei and Weinstein, 2023). This adaptability extended to other aspects of life, such as students who transitioned to socially distanced virtual classes, where introverted individuals demonstrated greater tolerance for this new paradigm (Sanudin *et al.*, 2022).

It's important to note that while social engagement, perception of support, and loneliness often interact significantly, they may not be inherently interconnected. Among older adults facing a reduction in support and social networks, individuals may form tighter-knit

relationships with their remaining social circle, adjusting their expectations so that reduced engagement doesn't necessarily lead to feelings of isolation (Cornwell and Waite, 2009).

Considering the introverted personality type, which experiences similar challenges as those associated with social isolation, can be beneficial. While interventions don't need to favour introverts over extroverts, they should address the needs and preferences of users, including the facilitation of supportive social networks (Mund and Neyer, 2019; Buecker et al., 2020; Card and Skakoon-Sparling, 2023). Research has demonstrated that both personality types can face issues related to social isolation to varying degrees, depending on numerous factors. This highlights the importance of designing interventions that are inclusive and accessible to individuals across the introversion/extroversion spectrum.

2.8 Preliminary Research Summary

The issue of social isolation extends far beyond the confines of the COVID-19 pandemic, affecting various demographics including the elderly, impoverished, and chronically ill. While previous research primarily focused on the elderly, recent studies have revealed that social isolation is prevalent across diverse age groups, including healthy middle-aged individuals. Understanding the nuances of social isolation, including its association with introverted personality types, is crucial for developing effective interventions. To guide intervention development, frameworks such as Hwang et al.'s (2020) social intervention categories and the distinction between objective and subjective isolation can provide valuable insights.

> *"There is no one-size-fits-all approach to addressing loneliness or social isolation, and*
> *hence the need to tailor interventions to suit the needs of individuals, specific groups*
> *or the degree of loneliness experienced. Therefore, future research should be aimed*
> *at discerning what intervention works for whom, in what particular context and how."*
>
> - 'Loneliness and social isolation interventions for older adults: a scoping review of reviews,'
> Fakoya, McCorry and Donnelly, 2020.

Despite the growing recognition of social isolation as a significant public health concern, research on loneliness interventions, particularly in the realm of HCI, remains limited.

Existing interventions often lack effectiveness and fail to address the diverse needs of users. Leveraging new technologies presents a promising approach to combat social isolation, but it requires careful consideration of users' preferences and technological proficiency. Tailoring interventions to specific groups and individual circumstances is essential, as there is no one-size-fits-all solution to addressing loneliness. Future research should focus on filling knowledge gaps in socio-technical interventions and exploring innovative approaches beyond traditional social media platforms.

Chapter 3. Co-Design Workshops

The co-design workshops were conducted with the aim of encouraging participants to share detailed experiences of social isolation. The goal was to gain deeper insights into the subject matter and leverage the creative input of participants to generate potential solutions.

3.1 Workshop Methodology

3.1.1 Workshop Design

The co-design workshops were conducted as part of a qualitative research approach, which is well-suited for gathering in-depth contextual information about subjective experiences and perspectives, especially when statistical measurements are not suitable (Hammarberg, Kirkman and De Lacey, 2016). This research method involves small-group discussions and structured interviews to explore concepts and viewpoints on a specific topic from individual participants' perspectives.

Since the study aimed to explore subjective loneliness and isolation experiences through the lens of individual participants, a qualitative research approach was chosen as the most appropriate. To organise the data gathered by the co-design workshops, Hwang et al.'s (2020, P1218) social intervention categories of 'maintaining basic needs,' 'managing emotions,' and 'keeping connections' offered a useful framework. It was hypothesised that most, if not all, examples of interventions should fit within one - or more - of these categories, though it may be interesting to investigate responses which do not fit into these archetypes. This approach allowed participants to provide subjective interpretations of their own experiences as well as those of people within their immediate social networks. The primary focus was on understanding individual experiences of loneliness and isolation, identifying common causes, and exploring the coping mechanisms participants used to address these challenges. The goal was to uncover recurring themes in participants' experiences through the collective data gathered during the workshops.

During the two-hour workshop sessions, participants actively shared their ideas and firsthand experiences related to various aspects and challenges of social isolation. These

collaborative sessions were designed to collect a wide range of data on the topic, forming the basis for developing detailed socio-technical interventions.

3.1.2 Participants

The workshops were conducted with 8 groups, with 3-5 participants in each group, resulting in a total of 33 individuals with first-hand experience of long-term social and/or physical isolation. Participants were recruited through personal social networks and social media platforms. The inclusion criteria required participants to:

- Be over the age of 18,

- Be English speaking,

- Have experience of social or physical isolation,

- Have access to a computer, internet, and voice communication tools.

Vulnerable groups, such as children or those with cognitive impairments, were not included.

All participants were informed of the procedures and requirements of the research project, that participation was entirely voluntary, and that written consent was required to take part. Volunteers were given a short interview before the workshop to ascertain their pre-existing experience and to gather cursory demographic information.

Due to recruitment challenges and scheduling delays caused by the researcher's illness, the study proceeded with 8 groups of 3-5 participants each, for a total of 33 individual participants. Workshops were conducted in English and recorded using digital audio recording tools. Participants had the option to choose communication platforms from several options, with all groups opting to utilise the Discord platform (Discord, 2023). All platforms utilise the same audio features and were recorded using the same Open Broadcaster Software (OBS) recording setup (OBS Studio, 2017). The choice of platform did not affect the data collection process and was offered to make it easier for participants to be included.

Given the sensitive nature of loneliness and isolation, participants were allowed to set boundaries for the discussions if certain topics were uncomfortable or difficult for them to

discuss. However, no limitations were needed as all participants were willing to share their experiences.

3.1.3 Locality

Because of constraints due to the health of the researcher, the workshops could not be undertaken as in-person focus groups. Instead, the groups gathered online using the communication platform Discord (Discord, 2023), and the workshops were produced using the web-based digital whiteboard software Miro (Miro, 2023).

A drawback of this environment was that the video conferencing tools being used were not as efficient at relaying subtle audio or visual cues between participants, and so the researcher may have missed some nuances of context or body language.

Because this locality required participants to interact with an online platform that very few of them had any prior experience with, each session began with a short introductory discussion and explanation of the main tools. While this made the workshop sessions less intuitive compared to a traditional in-person discussion and brainstorming session, the process was streamlined enough to minimise issues and distractions.

3.1.4 Procedure

The data collection process involved conducting semi-structured co-design workshops with participants organised into small groups. These workshops aimed to gather insights into the participants' experiences of loneliness and isolation, as well as their recommendations for solutions and coping strategies. This data would inform the design of socio-technical intervention prototypes later in the study.

When the participants for a workshop were all logged into the Miro platform (Miro, 2023), they would be given a brief introduction to the platform by the researcher, to familiarise them with the basic tools they may require during the workshop. The workshop then proceeded with the researcher describing the goals of a section, and then allowing the groups free rein to discuss and produce responses, before moving on to the next section in turn. There was no fixed time allowance for each section, with the researcher choosing when to move along

depending upon the momentum of the discussion, within reason dependent upon the allotted overall time for the entire workshop.

The semi-structured guidance for the co-design workshops aimed to facilitate open-ended discussions, and consisted of two main sections with an intermediary component:

1. Personal Experiences: This section was broken down into three major components:

- **Causes:** Gathering examples of factors contributing to or exemplifying isolation.

- **Effects & Symptoms:** Collecting examples of physical, mental, emotional, and behavioural changes and challenges resulting from loneliness and isolation.

- **Coping Mechanisms:** Gathering examples of strategies participants employed to overcome or alleviate the challenges identified in the previous component.

2. Identify and Evaluate: Information and comments from the previous section were reviewed, and the group selected a few examples from each component that they deemed most important for further examination. Particular attention was given to identifying causes lacking effective interventions and exploring opportunities to enhance existing interventions through HCI-based design solutions.

3. Define and Design: Groups chose from the reduced selection of examples and brainstormed HCI-based design concepts aimed at addressing specific causes, symptoms, or enhancing existing solutions and coping mechanisms.

Visual aids on the whiteboard guided the groups through the workshop, and responses were recorded as 'post-it' notes as shown in **Figs 3.1** and **3.4**. Audio recordings of the discussions complemented these notes, serving as comprehensive sources of data from each group.

The brainstorming sessions in which workshop groups generated design ideas during the '*Define and Design*' stage were also assessed and refined. These ideas were compiled into a catalogue of theoretical concepts, shown in **Chapter 4**, serving as inspiration for future ideation and development. This process, from workshop discussions through to the creation of demonstration prototypes, is outlined in **Fig 3.2**.

1. Personal Experiences 🌐

Group Experience
This workshop will begin by cataloguing personal examples and experiences of isolation, and any associated negative affects or symptoms. We will also gather examples of anything that helped you alleviate these symptoms, or any coping mechanisms you learned, and use this data in the later design stages.

Experiences

Direct Experience

Indirect Experience

Effects and Symptoms

Coping Mechanisms

Direct Experience

Indirect Experience

2. Identify and Organise 💡

Organising Data
This section will be used to organise the experiences and effects from the previous stage into lists, sorted by importance or priority. Use this to identify key issues and gaps in existing isolation interventions.
(Duplicate, not move, the notes from the previous stage).

Experiences

Effects & Symptoms

Coping Mechanisms

3. Define and Design 🧳

Defining and Designing
The group should now start choosing specific items to focus on. After picking an example, effect or mechanism, the group should then brainstorm and develop HCI design ideas and concepts to alleviate or enhance that concept.

Take Note Of:
1. How the design idea will help counter the issue.
2. What is needed to complete or enhance the design.
3. Presence and User Interactions.

Design Target 1

Basic Idea

Fig 3.1 - Example image of prepared whiteboard layout.
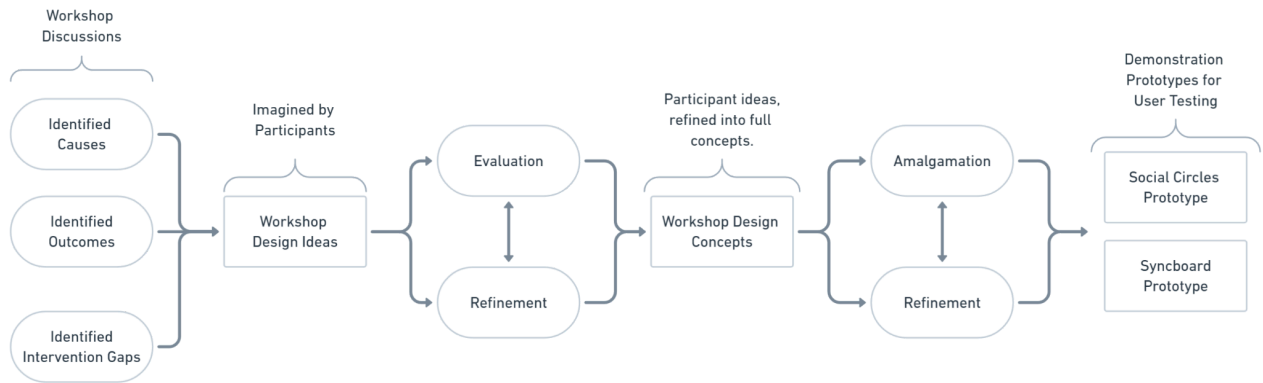
Fig 3.2 - Workflow from workshop discussion, through to prototype testing.

3.1.5 Data Handling & Analysis

After each workshop, the whiteboard panels were cloned into a single consolidated whiteboard for storage, as there was a limit on the number of concurrently 'live' boards. This amalgamated board was accessible only to the researcher and not shared with other participants. Following the completion of the workshops, the data was compiled and transcribed into an Excel document, securely stored on a password-protected OneDrive (Microsoft Corporation, 2023). The original audio recordings were stored on an encrypted hard drive, with exclusive access granted to the researcher. To protect participants' identities and maintain confidentiality, pseudonyms were assigned to all individuals. All data will be retained solely for the purposes of analysis and evaluation during the research project and will be securely destroyed in compliance with university guidelines upon project completion.

The audio recordings were transcribed into protected Word documents, and information from each workshop session was examined, with relevant data points incorporated into the Excel records where applicable (Microsoft Corporation, 2023). Post-workshop interviews were transcribed into protected Word documents, organised by anonymised pseudonyms (Microsoft Corporation, 2023).

With the research questions as a framework, the workshop responses were consolidated into single entries that encompassed theme of the response. These aggregated responses were then categorised into groupings of similar themes, types, or strategies using Inductive

Thematic Network Analysis, a qualitative analysis structure suitable for identifying and exploring emerging patterns and themes in qualitative datasets (Attride-Stirling, 2001; Elo and Kyngäs, 2008). The groupings were further organised into the lowest order 'basic themes,' which were grouped into broader 'organising themes' **(Fig 3.3)**. These organising themes were then categorised into higher order 'global themes.' For this research project, the initial global themes included Causes, Outcomes, and Interventions, although other global themes were also employed for in-depth analysis of specific themes and components. Based on the themes and categories generated by this analysis, an expanded set of research questions was formulated to guide the project through the primary prototype creation and evaluation phase of the study.
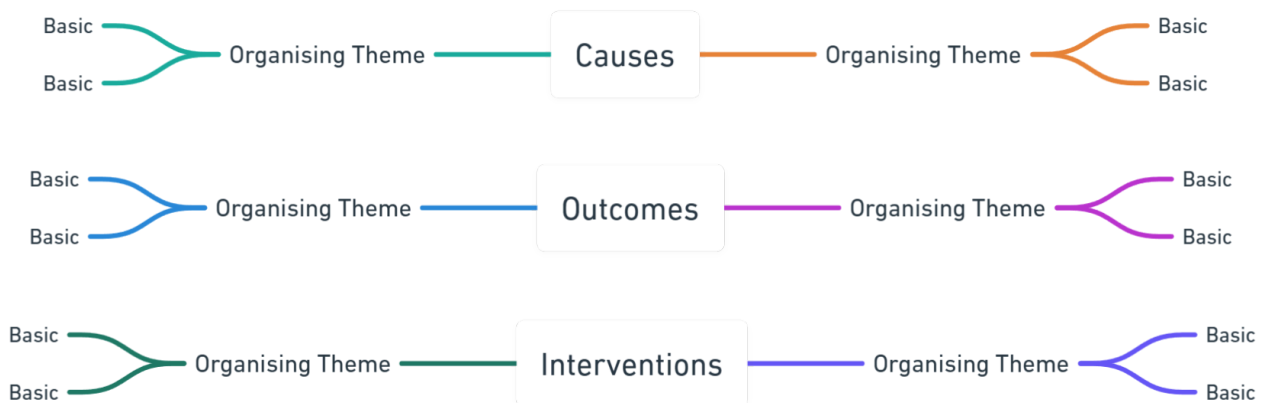
Fig 3.3 - Example of Thematic Network Analysis.

The analysis in this chapter focuses on three key components:

- **Causation Experiences:** Participants' narratives detailing the diverse causes of social isolation were documented **(Fig 3.4)**.

- **Effects & Symptoms:** The effects and symptoms that participants associated with social isolation were recorded.

- **Interventions:** Participants' insights into the existing pool of interventions designed to alleviate social isolation, along with coping mechanisms that were frequently utilised to mitigate the effects of loneliness and isolation.

These components were analysed by considering their frequency across workshop groups, and evaluated for their perceived significance and importance for future development, assessed through cumulative assessments of participant group responses.
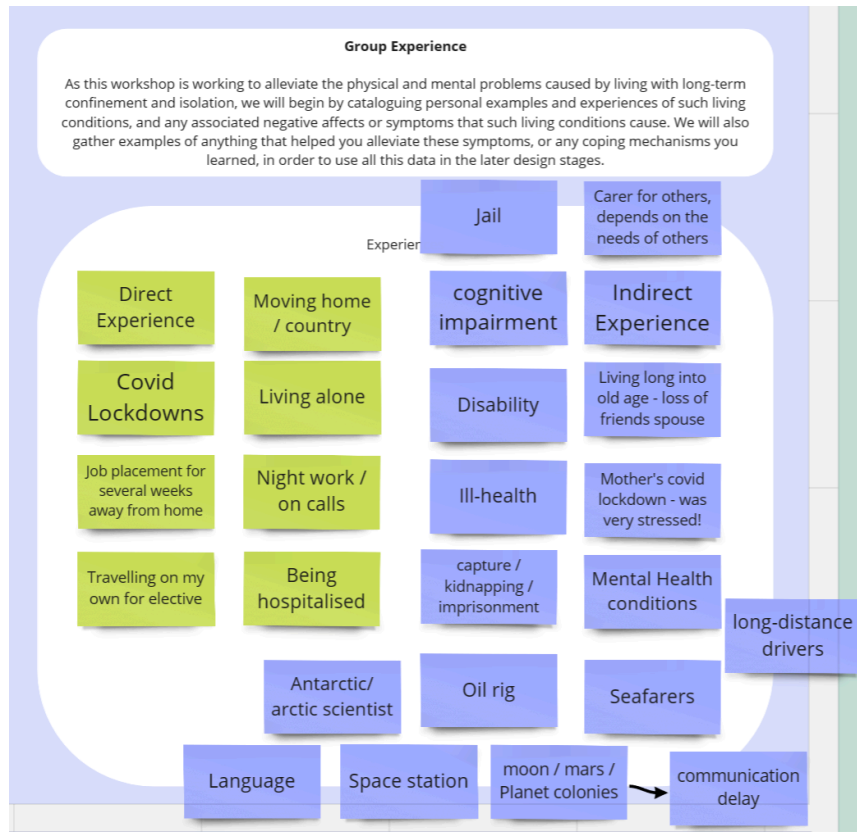
Fig 3.4 - Example of a workshop group panel on social isolation experiences.

After these discussions and data gathering stages were completed, workshop groups brainstormed ideas for HCI-based tools to support or replace social isolation interventions. The analysis of these ideas will be discussed in **Chapter 4** as part of the design and development of the concepts and prototypes.

The data analysis involved several stages of refinement to distil raw responses into coherent patterns. Responses with a high degree of similarity were synthesised into overarching themes. However, in cases where multiple participant groups attributed specific importance to similar responses, these were retained as distinct themes to capture subtle differentiations. For instance:
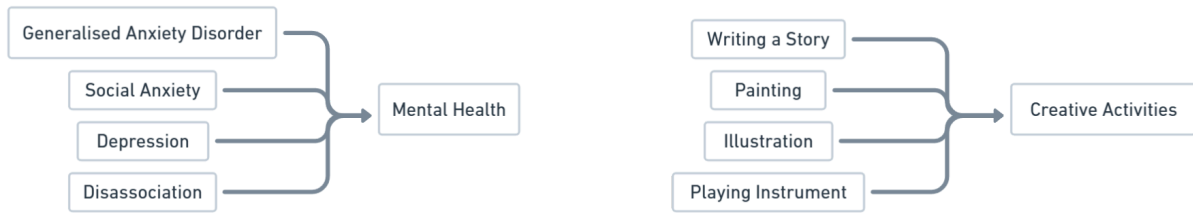
Fig 3.5 - Examples of amalgamated responses.

Additionally, responses with notably low incidence in workshop discussions were integrated into more substantial themes. However, to maintain clarity and focus, some responses were selectively excluded from the final dataset, particularly outliers and tangential responses not aligned with the research objectives. This selection process ensures that the findings presented are succinct and closely aligned with the central goals of this research.

3.2 Results & Findings

3.2.1 Causation of Isolation

In the analysis of the causes of social isolation, drawn from workshop discussions, four distinct themes emerged **(Fig 3.6)**:

1. Individual: This theme encompasses causations that originate from internal factors within the individual. These factors were frequently cited, indicating a high occurrence rate in the direct experiences of the participants. It includes two subcategories:

- **Physical:** These causes arise from physical limitations, such as disabilities, chronic illnesses, hospitalisation, and old age.

- **Psychological:** This category includes causes related to mental, emotional, or behavioural limitations, such as cognitive impairments, mental illness, drug abuse, and social dysfunction.
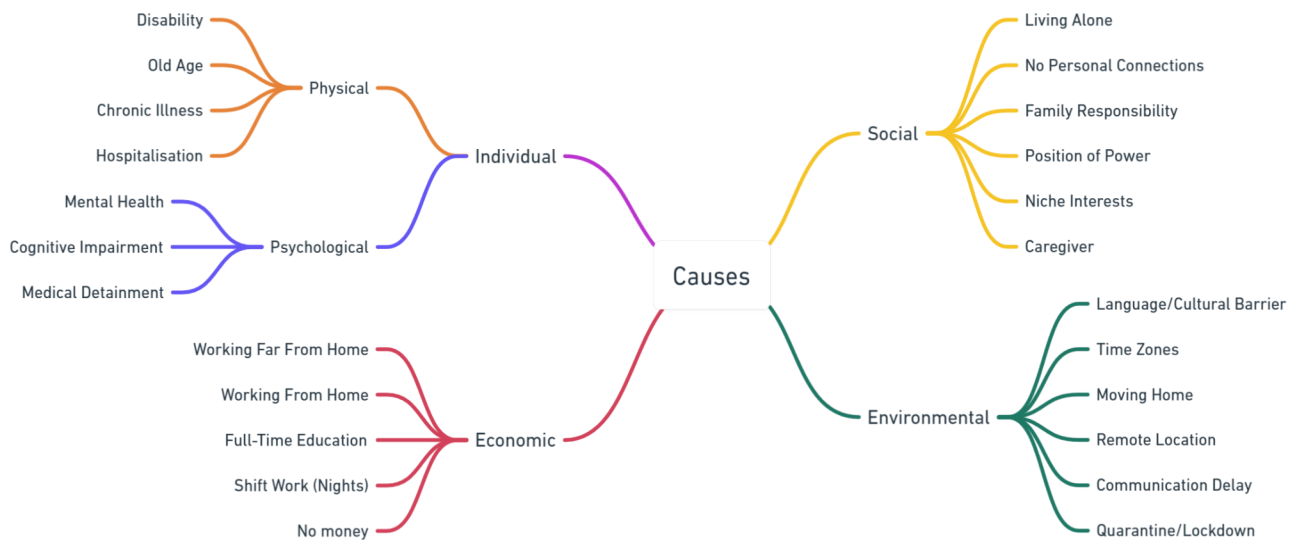
Fig 3.6 - Thematic network diagram of social isolation causations.

2. Social: These causes result from interpersonal dynamics among individuals or groups, including responsibilities within families, living in self-contained communities, and having a restricted network of social connections.

3. Environmental: Issues arising from the physical environment influence social isolation. This category includes living in remote areas, differing time zones from one's social network, and communication barriers in such regions.

4. Economic: Economic considerations also contribute to social isolation, including factors like remote employment, shift-working situations, and lack of financial resources. Full-time education falls within this category as well.

These categorisations provided a comprehensive understanding of the complex web of triggers that lead to social isolation. Notably, they emphasised the need for interventions that transcend in-person interactions, cater to individuals with physical and mental limitations, and address challenges related to remote locations and communication barriers. A common thread across multiple groups was the challenge of hectic work schedules, often resulting in limited time for socialisation. This underscores the importance of interventions that accommodate individuals with demanding work commitments.

A comparison of appearance frequency and designation of importance of social isolation causes.
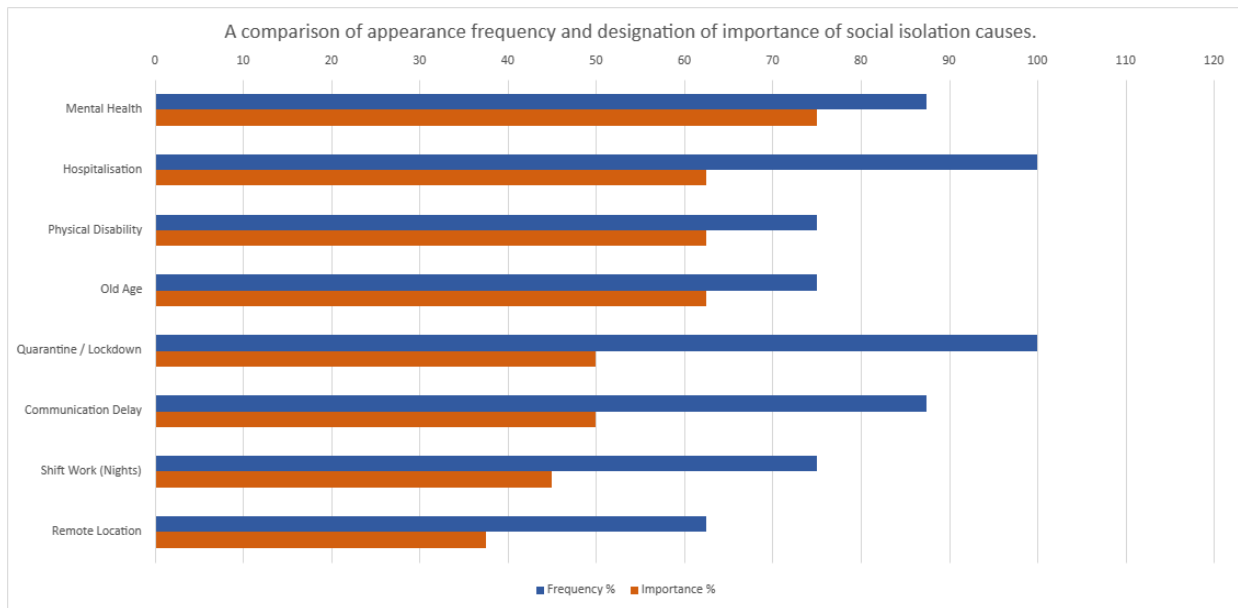
Fig 3.7 - Showing causes of isolation designated as important by more than 30% of participants.

> *"I work 10-14 hour days, depending on shifts and how the emergency patients turn up, and have a half hour commute. Between that and needing to spend my off-hours catching up on paperwork or housework, finding time to socialise is a luxury."*
>
> - Quote from workshop participant #D003, regarding their experience of social isolation.

As part of the workshop process, participants assessed and ranked the importance of various causations. This ranking serves as a guidepost in shaping the focus of future intervention design and development **(Fig 3.7)**.

Many of the significant factors contributing to social isolation are rooted in substantial limitations to physical or mental well-being. Chronic physical or mental illnesses, disabilities, and medical confinement in hospitals or quarantine frequently led to social isolation.

These factors hinder social engagement due to the inability to travel, creating a barrier to in-person interactions. As a result, there is a clear need for interventions that can facilitate social connections without the necessity for in-person interactions. This need is further emphasised by the prevalence of social isolation among individuals living in remote areas. While remote living doesn't inherently preclude travel, the practicality and feasibility of journeying to connect with a distant social network are often limited.

Additionally, other prominent factors contributing to social isolation include situations where communication delays are unavoidable. Similarly, scenarios involving shift work, especially

nightshift or swing-shift arrangements, can result in an individual's social schedule misaligning with that of their social network. These sources of isolation arise from the challenges of participating in real-time social activities. Consequently, interventions that enable asynchronous communication and social engagement hold the potential to provide significant benefits in addressing these issues.

Key takeaways:

- **Diversity of Causes:** Recognise the diversity of causations for social isolation, including internal, social, environmental, and economic factors.

- **A Hectic Life:** Consider the impact of demanding work schedules or extensive familial responsibilities on social isolation and design interventions accordingly.

- **Embrace Asynchronous Communication:** Design interventions that do not solely depend on real-time communication methods. Consider scenarios where communication delays or misaligned schedules are inevitable.

- **Accommodate for Limitations:** Prioritise interventions that accommodate individuals with physical and mental limitations, as these are prevalent causes of social isolation.

3.2.2 Impact of Isolation

In the next phase of the workshop discussions, the goal was to comprehensively catalogue the consequences, morbidities, and adverse outcomes of social isolation. These outcomes were categorised into four distinct categories **(Fig 3.9)**:
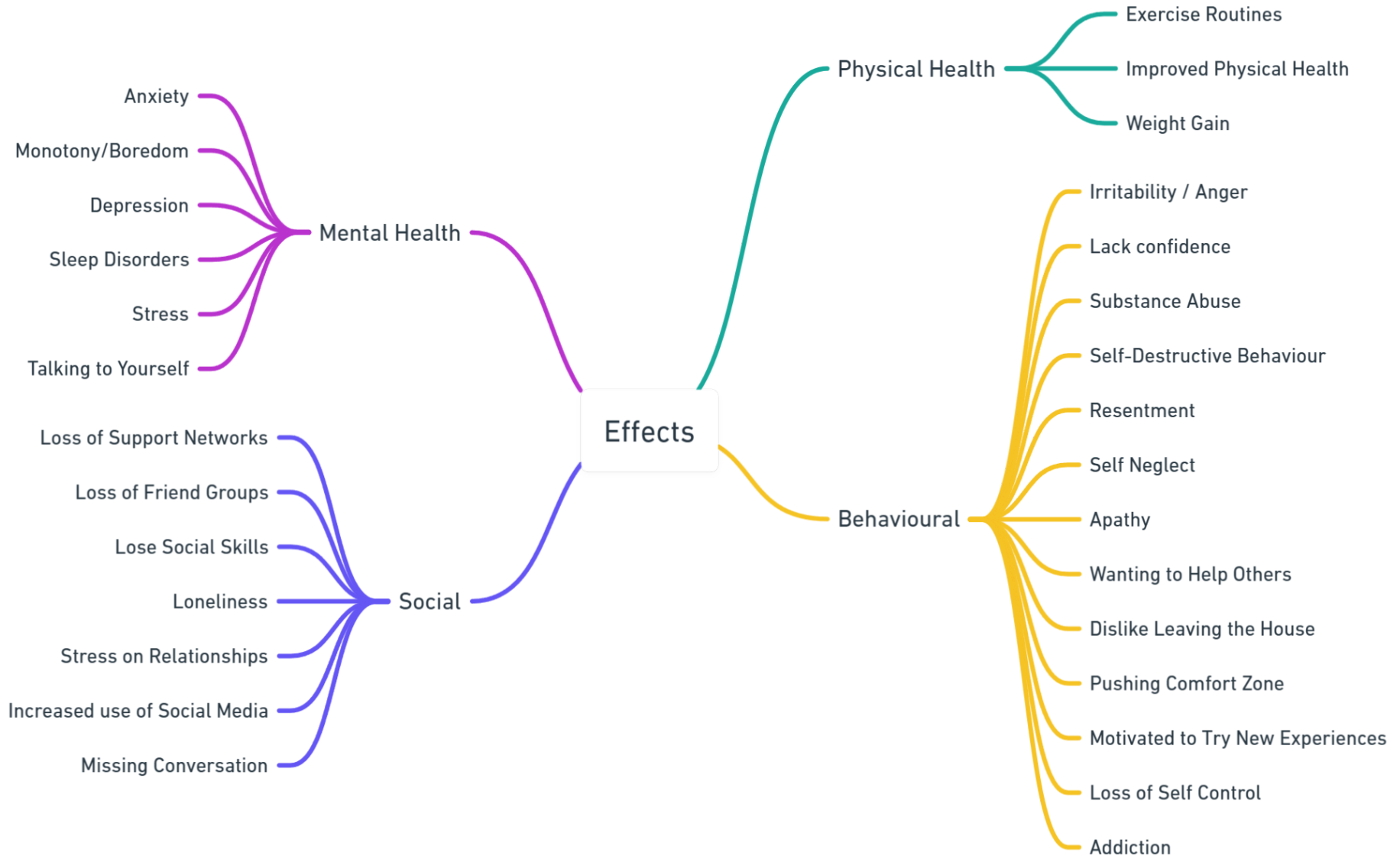
Fig 3.9 - Thematic network of reported effects of loneliness and isolation.

1. **Physical Health:**

Participants shared limited insights into the tangible physical effects of social isolation. While some positive outcomes, such as increased physical activity due to boredom, were noted, negative effects, such as unhealthy eating habits and weight gain, were also acknowledged. It's essential to recognise that social isolation can have more severe physical health consequences, including stress-related conditions and coronary heart disease, which may not be immediately visible but are nonetheless significant.
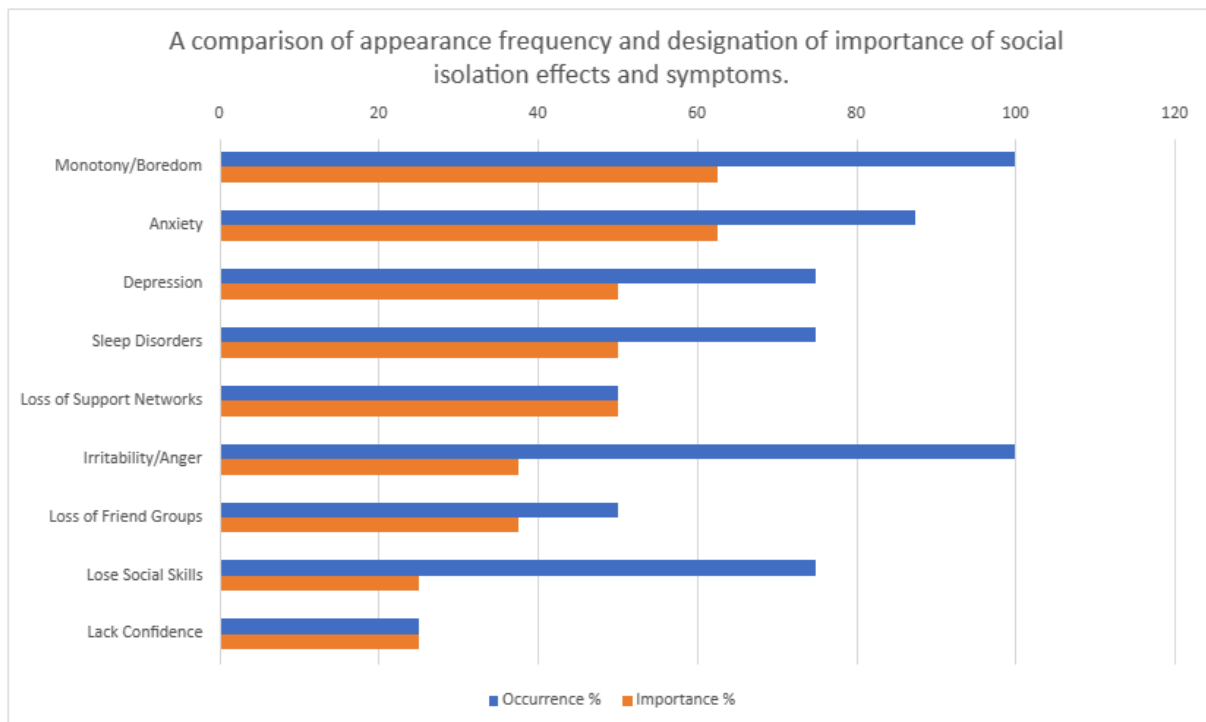
Fig 3.10 - Showing the reported impacts of isolation that were designated as important by greater than 30% of participant groups.

2. **Mental Health**

In the realm of mental health, participants recognised several significant consequences of social isolation. Most notably, the workshops revealed that feelings of boredom and monotony were universally acknowledged across all groups as a primary outcome **(Fig 3.10)**. These feelings, stemming from prolonged loneliness and isolation, were consistently identified as having a profound impact on individuals.

Following closely in importance were anxiety and depression, which were also widely acknowledged by participants as significant mental health issues associated with

social isolation. The sense of unease and sadness that accompanies these conditions was a shared concern among workshop participants.

Additionally, sleep disorders, encompassing both insomnia and hypersomnia, were recognised as prevalent consequences of long-term loneliness and isolation. Participants in various groups acknowledged the detrimental effects of social isolation on sleep patterns, highlighting the importance of addressing these issues when designing interventions to combat social isolation.

3. **Social Impact**

    This category encapsulates the erosion of an individual's social structure and foundation due to prolonged isolation. Loss of support networks, friendships, and strains on existing relationships were noted. Additionally, there is a decline in foundational social skills, such as recognising social cues and conversational proficiency. These effects can have lasting consequences on an individual's ability to form and maintain relationships.

4. **Behavioural Changes**

    The largest thematic segment within the effects category, behavioural changes encompass alterations in typical behaviour due to long-term isolation and loneliness. These changes include heightened irritability, resentment, reduced self-confidence, and an increase in instances of self-neglect and self-destructive behaviours. It's important to acknowledge that these changes can vary widely from person to person, underscoring the need for personalised interventions.

It is important to note that the workshop discussions primarily focused on effects that participants were familiar with or had experienced directly. However, social isolation can have a more extensive range of consequences, such as coronary heart disease and stress-related comorbidities (Heffner *et al.*, 2011; Steptoe *et al.*, 2013). These broader effects should be considered when designing interventions to address social isolation effectively.

Key Takeaways:

- **Holistic Impact:** Social isolation has a multifaceted impact, affecting physical health, mental health, social relationships, and behaviour.

- **Boredom and Monotony:** Feelings of boredom and monotony are universally recognised as primary consequences of social isolation. Addressing these feelings is crucial in combating loneliness and isolation effectively.

- **Mental Health Challenges:** Anxiety and depression are significant mental health issues associated with isolation. Solutions should aim to alleviate these conditions.

- **Erosion of Social Structure:** Prolonged isolation erodes social structures, leading to the loss of support networks, strained relationships, and diminished social skills, highlighting the need for interventions that address these challenges.

- **Behavioural Changes:** Long-term isolation can lead to behavioural changes, including irritability, reduced self-confidence, and self-neglect. Personalised interventions should address these varied effects.

3.2.3 Social Isolation Interventions

To explore the commonly utilised pool of existing solutions, the collection of interventions was organised into a thematic framework proposed by Hwang et al. (2020). This framework categorised interventions into three overarching themes: Maintaining Basic Needs, Managing Emotions & Psychiatric Symptoms, and Keeping Connections **(Fig 3.11)**.

Within these thematic categories, I further classified interventions into subcategories:

Behavioural: These interventions relate to coping strategies and behavioural patterns individuals employ to navigate the challenges of loneliness. Examples include maintaining daily routines and cultivating a positive outlook.

Social: This category encompasses activities that involve engagement with social networks and support structures. This includes spending time with family and friends, as well as utilising video conferencing tools to sustain connections with social groups.
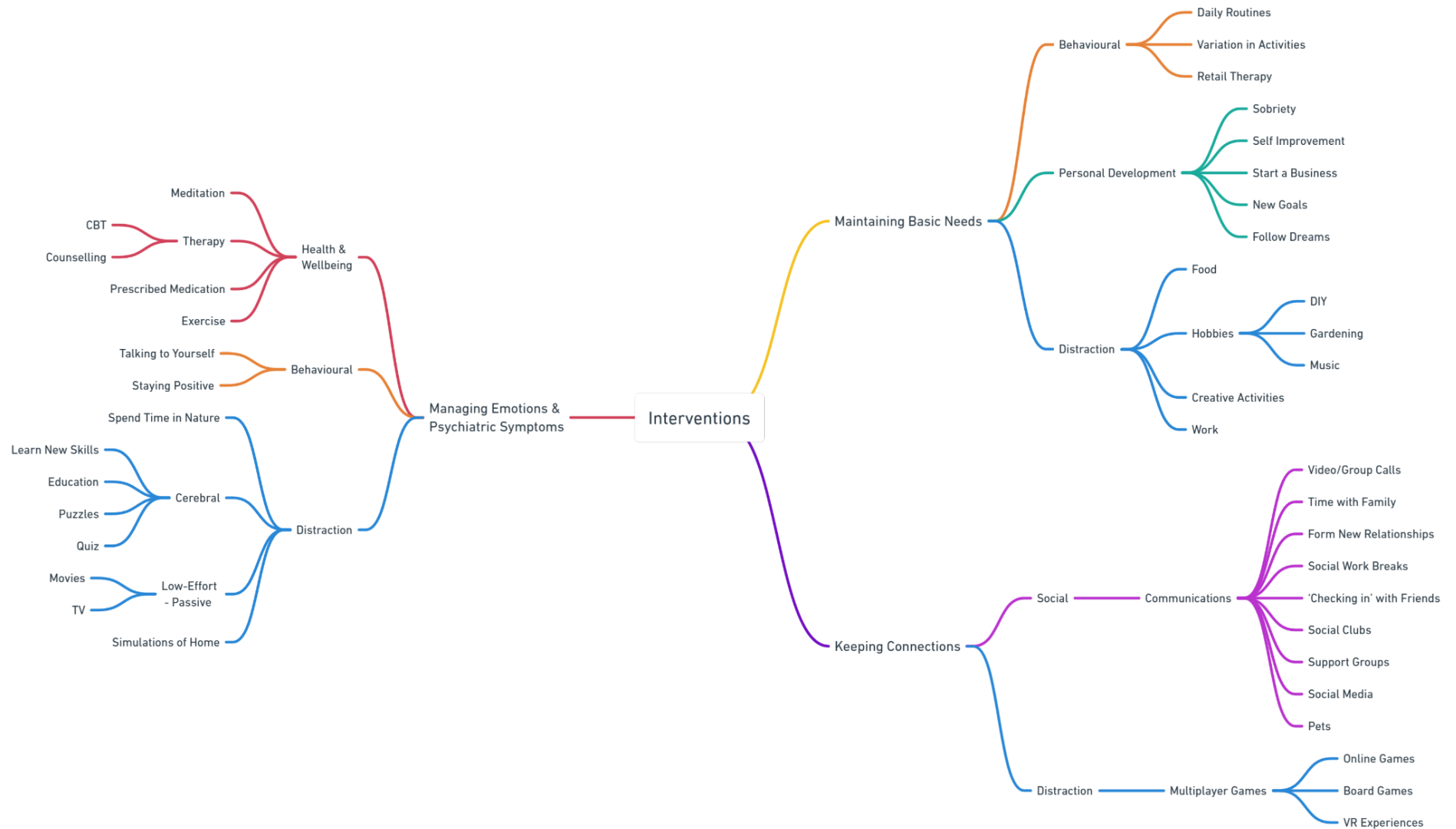
Fig 3.11 - Thematic network of showing organisation of existing interventions.

Distraction: Interventions in this category aim to divert individuals' attention away from feelings of loneliness and isolation. This encompasses a wide spectrum of activities, from creative pursuits to cerebral endeavours, including passive activities like watching television and movies.

Health & Wellbeing: Actions in this subcategory directly contribute to enhancing an individual's physical or mental health. These interventions include practices such as meditation, therapy, and adhering to a rigorous exercise regimen.

Personal Development: These responses focus on activities centred on self-improvement unrelated to physical or mental health. Examples include acquiring new skills, pursuing personal goals, and initiating new business ventures.

It is important to note that the collection of interventions presented here represents only the strategies and coping mechanisms identified by participants during co-design workshops. Certain traditional or contemporary interventions may have been missed, due to limitations in the demographic or personal backgrounds of participants. While the goal was to encompass as broad a range of interventions as possible, some specific interventions were purposely omitted from the final thematic analysis. These omissions primarily included interventions with negative connotations, such as those arising from psychological issues such as disassociation or involving self-destructive behaviours such as alcohol or substance abuse. Instances of becoming violent were also omitted, particularly if related to anger or emotional instability. However, the theme of 'exercise' includes pseudo-violent activities such as boxing as a form of frustration relief, which remains relevant.

To better facilitate the development of socio-technical intervention tools, I have expanded upon the existing framework by introducing two new organisational themes: **synchronous** and **asynchronous** interventions **(Fig 3.12)**. This reconfiguration is aimed at enhancing the framework's practicality and adaptability.
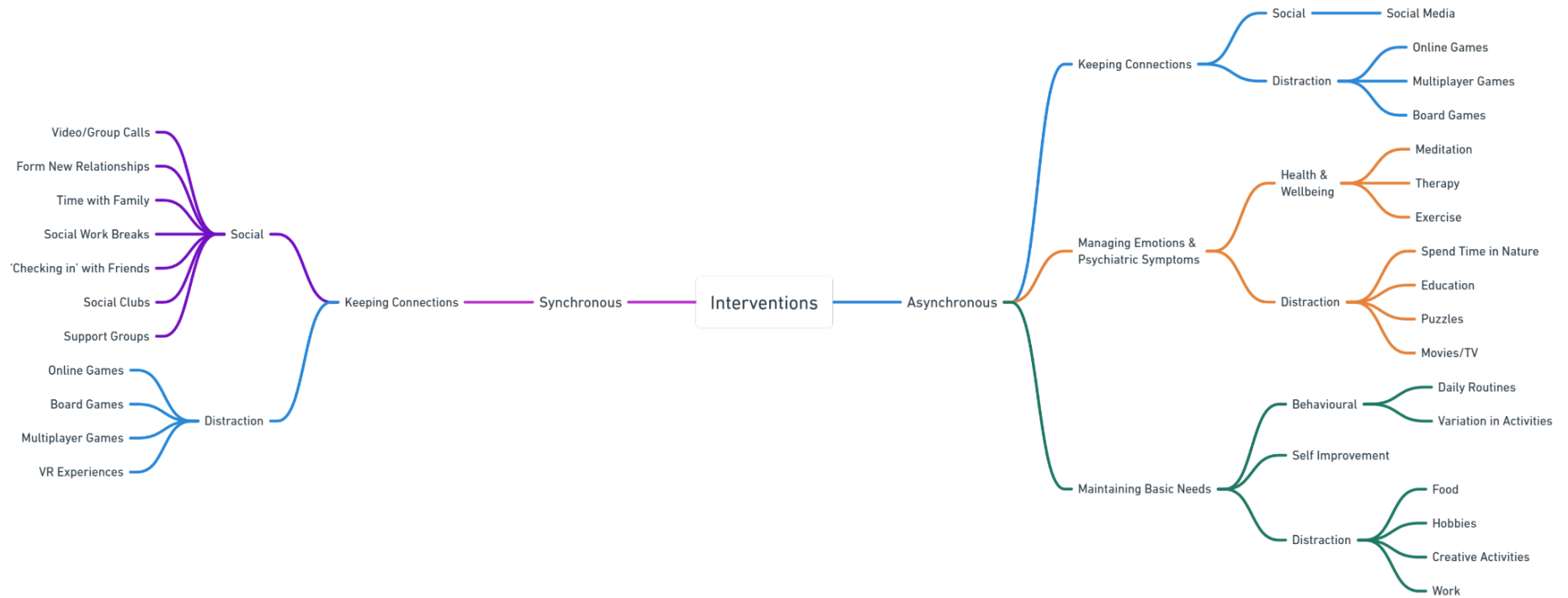
Fig 3.12 - Thematic network diagram showing interventions organised by synchronisation type.

In this context, **synchronous interventions** involve coordinated real-time interactions among individuals who come together at a specific time and place, whether in physical or virtual settings. Examples of synchronous interventions include in-person gatherings at venues like pubs, spending quality time with family and friends, or using online platforms that support real-time multiplayer gaming. Conversely, **asynchronous interventions** do not necessitate real-time coordination among members of a social network. These activities involve interactions that occur over more extended periods and can be tailored to individual schedules without requiring prior coordination. Some asynchronous interventions involve various forms of interaction, such as turn-based gaming or text-based messaging applications. Others focus on individual engagement, like pursuing hobbies, engaging in creative tasks, or seeking personal improvement through therapy and meditation.

It's noteworthy that post-workshop interviews shed light on practical dynamics related to these interventions. Participants favoured asynchronous activities for their adaptability to daily routines and the flexibility they offer, enabling pressure-free social interaction at their own pace. The interviews further underscored the challenges associated with fostering effective synchronous engagement, emphasising scheduling difficulties and geographical constraints as significant hurdles. The necessity to coordinate participants' schedules emerged as a key barrier, with the failure to do so resulting in missed opportunities for social interaction. Additionally, some participants expressed reluctance or difficulty in travelling considerable distances or stepping out of their comfort zones for physical attendance. These insights provide a nuanced understanding of the multifaceted nature of social isolation and offer critical considerations for intervention design that can effectively bridge social gaps and address isolation challenges.

These insights shed light on why asynchronous activities made up a substantial proportion of interventions that were considered important for further examination and potential inclusion in the socio-technical intervention design phase of this study. Among these interventions, a significant portion belongs to the 'Distractions' category, which encompasses activities aimed

at diverting attention from feelings of loneliness and isolation. While this category spans both synchronous and asynchronous realms, it leans more toward the latter.
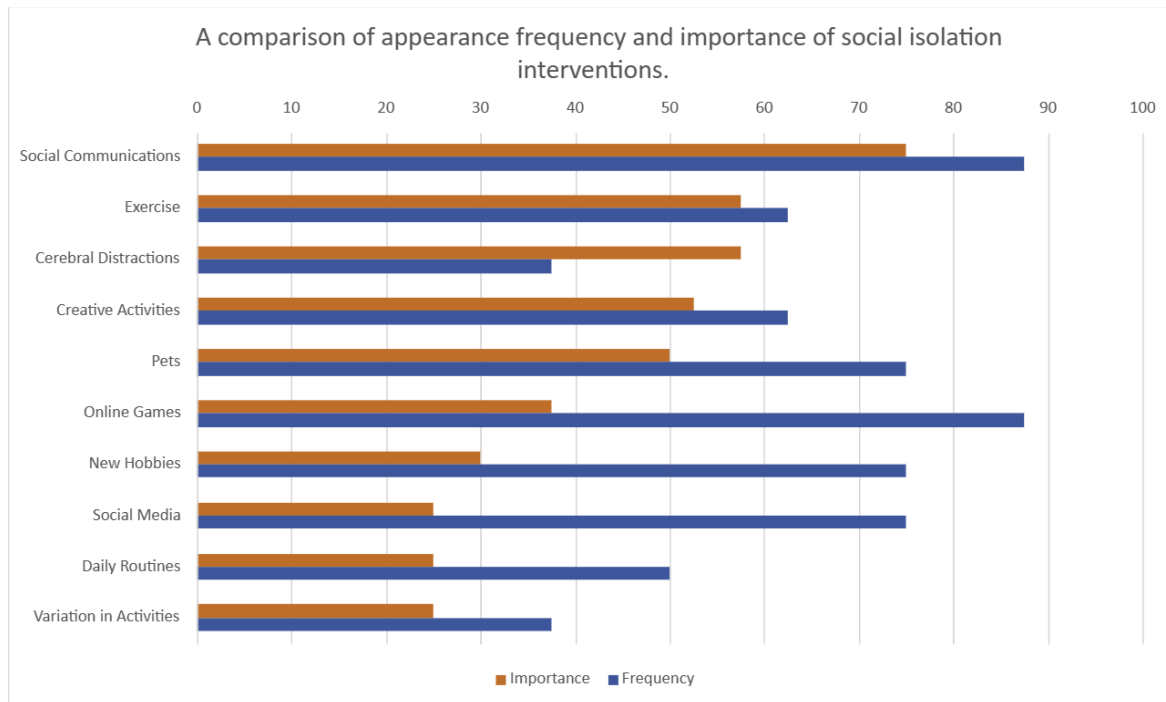
Fig 3.13 - Showing the interventions that were designated as important by < 25% of participants.

Notably, online multiplayer games emerged as a significant intervention type within the 'Distractions' category, blurring the line between synchronous and asynchronous engagement **(Fig 3.13)**. These games, especially those reliant on real-time communication and activity, offer opportunities for social interaction without the constraints of scheduling and geographical proximity. Other prominent interventions in the 'Distractions' category include creative activities, exercise, and cerebral distractions such as reading and solving puzzles. These findings highlight the importance of considering asynchronous interventions and the role of distraction activities in combating social isolation effectively.

Key takeaways:

- **Synchronous vs. Asynchronous Interventions:** recognise the significance of both synchronous and asynchronous interventions. While asynchronous activities offer adaptability and flexibility, synchronous activities can foster real-time social interaction. Consider the practical challenges, such as scheduling difficulties and geographical constraints, associated with synchronous engagement.

- **Popularity of Distraction Interventions:** Distraction interventions, which divert attention from feelings of loneliness and isolation, were prominently recognised. These interventions encompass a wide range of activities, including online multiplayer games, creative pursuits, exercise, and cerebral distractions.

- **Bridging Social Gaps:** Effective intervention design should bridge social gaps and address isolation challenges. Consider the preferences and constraints of individuals facing social isolation to develop tailored interventions that meet their needs.

3.2.4 Co-Design Workshops: Summary

This chapter explored the realm of social isolation through co-design workshops, interviews, and rigorous data analysis. The exploration revolved around three pivotal aspects: the root causes of isolation, the consequences, and the landscape of existing interventions. A meticulous data analysis process allowed for the extraction of meaningful themes, uncovering patterns that offer profound insights into the intricate nature of social isolation.

Causes of Isolation: Participants identified four primary themes contributing to social isolation: Individual, Social, Environmental, and Economic factors. Notably, challenges related to physical and mental health, as well as work-life balance issues associated with remote work and changing schedules, emerged as significant contributors to isolation. These findings underscore the necessity of interventions that go beyond in-person interactions and real-time communication to support individuals restricted from social engagement due to distance or scheduling barriers.

Consequences of Social Isolation: The consequences of social isolation were categorised into four groups: Physical Health, Mental Health, Social Impact, and Behavioural Changes. Key outcomes from the workshops included mental health challenges, the erosion of support networks, and emotional and psychological distress resulting from boredom and monotony. These findings highlight the paramount importance of addressing mental health effects and mitigating the loss of social structures. They also emphasise the need for interventions that

combat boredom and engage individuals' minds while fostering and strengthening social support networks.

Social Isolation Interventions: Interventions spanned various subcategories, such as Behavioural, Social, Distraction, Health & Wellbeing, and Personal Development. The distinction between synchronous and asynchronous interventions highlighted the appeal of flexibility and convenience in asynchronous activities while also revealing challenges related to scheduling and geographical barriers in synchronous social engagements. Workshop participants expressed a fervent desire for distraction-based tools that support cerebral or creative pursuits.

Additional - Introversion vs Extroversion: The workshop discussions shed light on the interplay between introversion, extroversion, and social isolation. Participants observed that, under typical circumstances, introverts may be more susceptible to social isolation due to their inherent tendencies. However, during periods of enforced isolation, introverts appeared to adapt more effectively than extroverts (Glei and Weinstein, 2023). This underscores the complex relationship between personality traits and adaptability to social isolation. As a result, this awareness has been integrated into the background research of this project for reference during the subsequent intervention prototype development and testing phase. This enabled exploration into how the preferences of introverted and extroverted individuals influence the effectiveness of socio-technical interventions, ensuring that potential solutions remain inclusive across diverse psychological profiles.

With the data gathering phase of the workshops ending, the workshop groups proceeded to leverage their lists of causes, outcomes, and existing interventions to identify gaps and limitations that could potentially be addressed through HCI-based tools. In **Chapter 4**, the ideas and inspirations that emerged from these group discussions will be outlined as a **catalogue of intervention concepts**.

Overall Analysis and Key Takeaways:

- **Causes of Isolation:** Social isolation stems from a range of factors, including physical and mental health challenges, work-related issues, living in remote areas, and communication barriers. Interventions should address these diverse causes.

- **Consequences of Social Isolation:** Social isolation has significant consequences, particularly on mental health, including feelings of boredom and monotony, anxiety, depression, and sleep disorders. It also erodes social structures and leads to behavioural changes.

- **Social Isolation Interventions:** Interventions fall into categories like Behavioural, Social, Distraction, Health & Wellbeing, and Personal Development. There's a distinction between synchronous and asynchronous interventions, with asynchronous activities favoured for their flexibility.

- **Asynchronous vs Synchronous:** Asynchronous interventions offer adaptability to daily routines and flexible social interaction, while synchronous interventions face challenges related to scheduling and geographical constraints.

- **Importance of Distractions:** Distraction-based interventions, including creative activities, exercise, and cerebral pursuits, play a vital role in diverting attention from loneliness and isolation. These interventions are highly valued by participants for their positive impact on mental well-being.

- **Introversion vs Extroversion:** The interplay between introversion and extroversion may influence how individuals experience and adapt to social isolation. Workshop participants theorise these differences may be crucial for designing inclusive interventions.

- **Gap Identification:** The workshops identified gaps and limitations that could be addressed through HCI-based tools and used them as inspiration for innovative intervention ideas and concepts - catalogued in **Chapter 4**.

Chapter 4. Catalogue of Intervention Concepts

After their discussions on the causes, effects, and existing interventions related to social isolation, the co-design workshop groups engaged in a creative ideation process. These collective brainstorming sessions aimed to explore potential avenues where technology could be harnessed to address the identified challenges of social isolation. These ideas, grounded in real-world narratives and firsthand experiences, served as the foundation for the subsequent design and development of a pair of working prototypes. This process not only facilitated the synthesis of inspiration from diverse sources, but also provided insights into how individuals envision the potential of technology in combating isolation and loneliness.

In **Section 4.1**, these inspirations and ideas have been refined and combined into a catalogue of workshop concepts. This catalogue includes a general description of each concept, an evaluation of included features, and an assessment of their feasibility for development into working prototypes.

After the concept evaluation process, these workshop concepts served as the foundation for creating two final prototype interventions - one synchronous in design **(4.3)**, and one asynchronous **(4.4)**. These prototypes are each outlined in detail, including key features and the evolution of the designs from workshop concept through to the creation of functional demonstration models. These demonstration models will be used in subsequent chapters for user-centric testing and analysis, to evaluate and compare the benefits and limitations of synchronous and asynchronous socio-technical interventions.

4.1 Workshop Concept Generation and Evaluation

> *"Just give me my Holodeck. It would solve all our problems!"*
> - Quote from participant #J025 during workshop discussion on intervention ideas.

During this phase, workshop groups transitioned into a creative ideation process exploring potential uses of HCI-based tools to combat the challenges of social isolation. Participants were encouraged to brainstorm ideas freely, fostering creativity with minimal constraints. The objective was to collect diverse conceptual inspirations for future prototype development.

While creativity was valued, preference was given to ideas rooted in contemporary or emerging technologies rather than purely fantastical concepts. This balance aimed to ensure feasibility and practical implementation for demonstration testing.

Ideas that resulted in intervention concepts were evaluated for efficacy, feasibility, and alignment with workshop themes. Similar concepts were merged, while outlier suggestions were noted as 'Variant' concepts. The focus was on their suitability for prototype development and live demonstration testing with participant social groups, to assess real-world effects on isolation and loneliness metrics.

4.1.1 Concept 1 - 'Alone Together'

Context: The 'Alone Together' concept addresses the isolation experienced by hospital patients. Hospitalisation often intensifies feelings of loneliness due to abrupt changes in surroundings and health conditions. The extended stays in hospitals, particularly for non-sedated cases, were found to be monotonous, lacking opportunities for typical distractions and interactions. Multiple workshop groups proposed variations of this concept, focusing on challenges faced by patients, leading to the amalgamation of these suggestions into a single proposal.

Fig 4.1 - An iPad set up for video calls during COVID-19, courtesy of Upstate Medical University.

Concept Outline: Workshop participants envisioned a personalised touch-screen device for every hospital patient **(Fig 4.1)**, offering entertainment, communication tools, games, and exclusive access to a patient-only social network **(Fig 4.2)**. This 'Alone together' social network would be a virtual community for patients to connect, communicate, and support each other, fostering the exchange of stories, advice, and camaraderie. It offers a space for patients to share experiences and challenges unique to their hospitalisation, helping to combat feelings of being misunderstood or alone. The platform also offers interactive gaming and shared distractions to provide respite from the hospital environment.

Additionally, the concept could be expanded to include features that could potentially assist patients with hospital-related questions and guidance. This holistic approach aimed to address both emotional and practical needs during hospital stays.
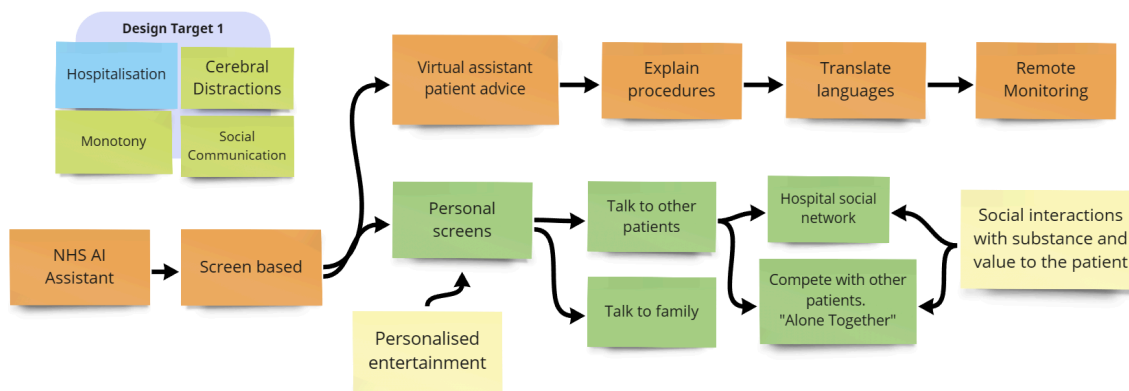
Fig 4.2 - Workshop design notes from Group 3 outlining the "Alone Together" concept.

Rationale: The idea emerged from discussions within the workshop groups regarding the isolating nature of hospitalisation. Workshop participants noted that in their experience, patients often find it challenging to share their feelings with friends and family, leading to the inspiration for a targeted solution that instead allows patients to communicate with other patients who have a common shared experience.

Pros: The concept utilises modern technologies and social tools to address hospital-related isolation. Creating a prototype social network for testing is feasible., though some features may be limited. It may be possible to utilise existing solutions for the demonstration.

Cons: Testing with actual patients in a hospital environment presents logistical and ethical challenges. Interventions based upon the use of social media are one of the few socio-technical tools that have been extensively studied, limiting the concept's novelty.

4.1.2 Concept 2 - Synchroni-Link

Context: The Synchroni-Link concept emerges as a dynamic solution that integrates artificial intelligence (AI) and social connectivity, enabling seamless and spontaneous interactions among friends. Recognising the contemporary challenges of maintaining regular and meaningful social interactions within busy schedules, the Synchroni-Link concept leverages AI to bridge this gap.

Concept Outline: At its core, Synchroni-Link features a sophisticated AI system that serves as a social facilitator **(Fig 4.3)**. It analyses users' ongoing activities and gauges their openness to social engagement. For instance, if someone is immersed in an activity such as drawing or gaming, the AI identifies this and assesses whether others in their friend group are engaged in similar or complementary activities.
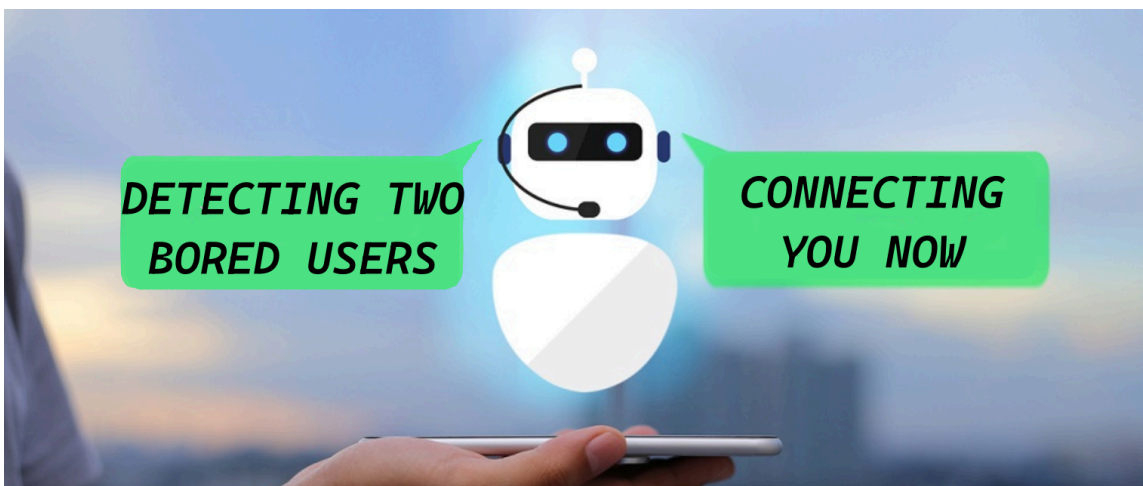
Fig 4.3 - A concept image of an AI helper connecting members of a social network.

When alignment is detected, it suggests potential social connections, allowing users to opt-in based on their preferences. If both parties agree, the AI initiates real-time connections, fostering shared experiences and camaraderie. Throughout the development of this idea, the workshops stressed the significance of privacy, underlining the importance of AI respecting users' preferences regarding the frequency and nature of their social connections.

Rationale: The Synchroni-Link concept addresses the challenge of maintaining strong social connections in today's hectic, fast-paced lives. This is achieved through the utilisation of AI, which detects moments of alignment and facilitates real-time connections. The goal is to revitalise friendships, promote shared activities, and nurture authentic interactions.

Pros: Synchroni-Link uses emerging technologies to support additional social engagement and expanding social connections while encouraging supportive or creative activities.

Cons: Developing an automated AI-based system for monitoring and organising social activities is extremely complex. Ethical and privacy concerns would need careful evaluation

4.1.3 Concept 3 - CPAP-VR

The CPAP-VR concept presents an innovative approach to alleviate feelings of isolation during intensive Continuous Positive Airway Pressure (CPAP) machine treatments **(Fig 4.4)** by leveraging cutting-edge virtual (VR) or augmented (AR) reality technology.

Context: During the COVID-19 pandemic, CPAP machines became widely used, especially in severe cases where patients needed a specialised 'hood' to assist with breathing. However, this treatment approach posed challenges that exacerbated feelings of isolation. Patients placed under the hood experienced reduced vision, muted hearing, and limited mobility, creating an environment akin to sensory deprivation or even solitary confinement.

Fig 4.4 - A render of a CPAP hood, showing how it can be visually and audibly isolating.

Concept Outline: The core concept behind CPAP-VR involves a transformative redesign of the CPAP hood, integrating essential components of VR or AR headsets. This integration immerses individuals undergoing CPAP treatment in a digital world, offering entertainment, communication opportunities, and the chance to explore diverse virtual environments. These experiences are designed to alleviate sensations of loneliness and confinement while fostering mental engagement, social connectivity, exploration, distraction, and emotional comfort.

Rationale: The CPAP-VR concept aims to address the isolation experienced by individuals undergoing extreme CPAP treatment, particularly those requiring enclosed hoods with limited mobility. By incorporating VR/AR technology into the treatment apparatus, this concept provides patients with immersive experiences that counteract the negative emotional impact of isolation, enhancing their psychological well-being during treatment.

Pros: Utilising emerging technologies to reduce feelings of isolation and support social communication aligns with key objectives of this research project.

Cons: Like the 'Alone Together' concept, evaluating this project would involve procedures beyond the capabilities of this research project. While it may be possible to assess this concept without a hospital setting, it would require creating physical components and establishing a long-term, in-person testing environment, which is infeasible for this researcher to implement.

4.1.4 Concept 4 - 'Messages in a Bottle'

Context: The 'Messages in a Bottle' concept tackles the challenge of substantial communication delays in interplanetary habitation, particularly between Earth and Mars, where communication latency can extend up to 40 minutes for a round trip **(Fig 4.5)**. Workshop participants contemplated the implications of losing instant communication in interplanetary living, foreseeing a resurgence of historic communication methods. In this context, traditional turn-based games, akin to chess or board games, regain popularity as they accommodate delayed responses from participants.
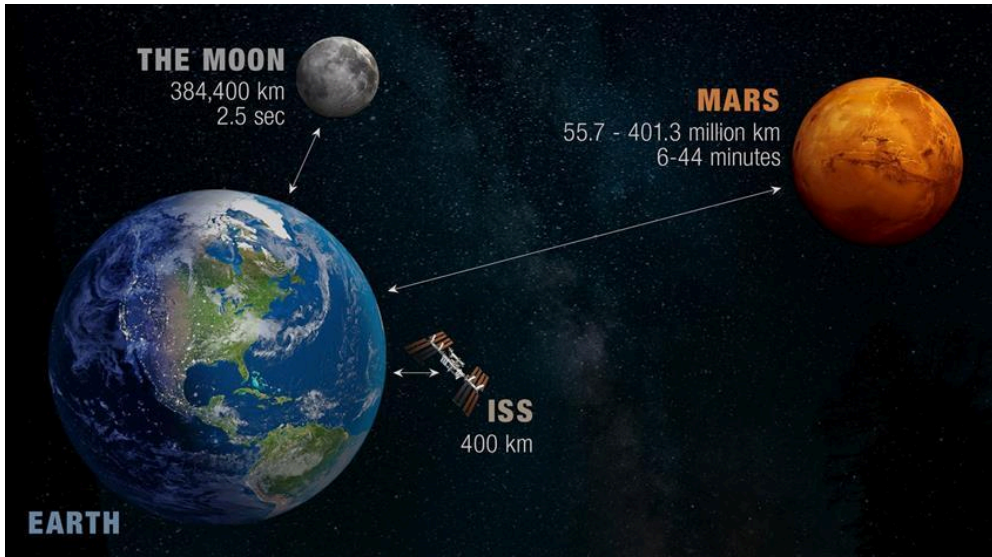
Fig 4.5 - A graphic showing the communication delay times for a Mars-Earth signal.

Concept Outline: This concept draws inspiration from historical long-distance communication methods, envisioning a modern revival of 'pen pals' style communication. In this digital era, the aim is to infuse periodic social updates with more substantial content, fostering meaningful exchanges between individuals. The communication process extends beyond mere text-based updates; participants can include additional content, such as video messages or game moves, transforming each interaction into a more engaging and interactive experience **(Fig 4.6)**.
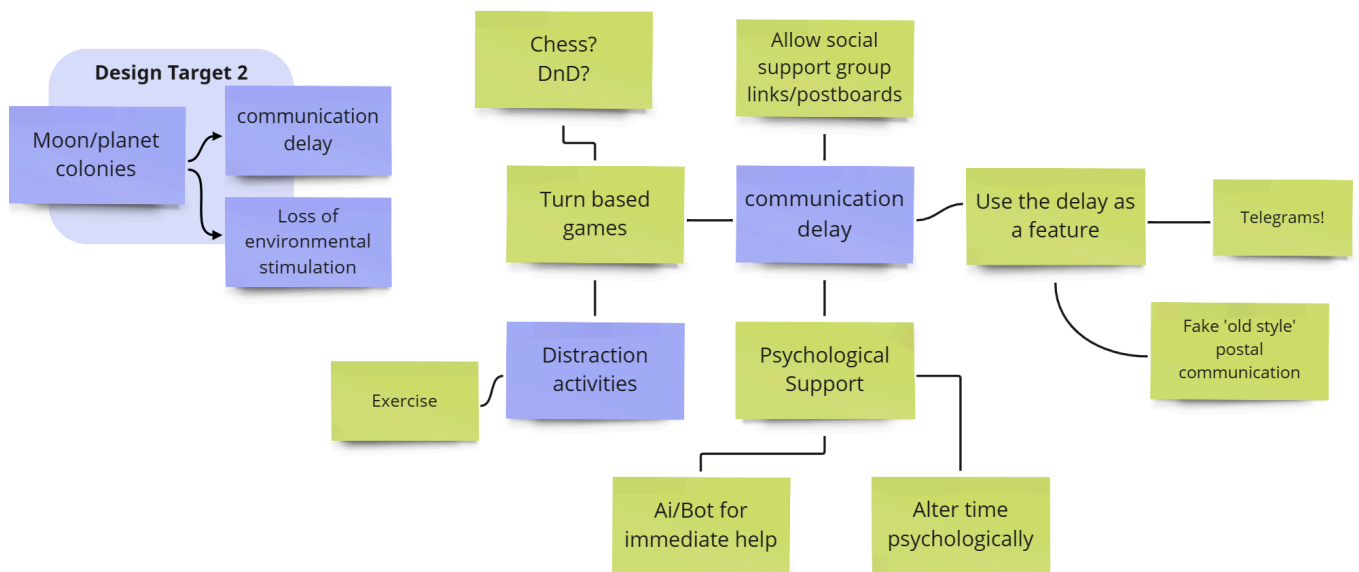
Fig 4.6 - Workshop design notes from Group 1 outlining the "Messages in a Bottle" concept.

Additionally, the concept explores the use of advanced technology to create interactive, holographic, or magnetically controlled game boards. These boards would automatically update pieces as turns unfold, offering a new dimension to traditional turn-based games.

Variant - Collaborative Creativity

One workshop variation on the theme of long-distance asynchronous communication included the premise that this form of content data delivery would also be compatible with computer graphics, particularly vector-based graphics. This would enable the sharing of artwork and even support collaborative artistic endeavours. Similar forms of collaboration could be facilitated, such as musical compositions, given the use of efficient audio compression techniques.

Rationale: The 'Messages in a Bottle' concept aims to modernise turn-based games and 'pen pal' style communication, recognising their value in interplanetary communication scenarios. It uses digital data as a medium, expanding the potential for diverse content delivery. This concept isn't limited to only interplanetary settings; it also addresses social isolation arising from scheduling conflicts or real-time communication challenges, whether due to communication latency or terrestrial factors like time zones and sleep patterns. It adapts traditional communication methods with technology, bridging social gaps in various situations, from interplanetary distances to contemporary scheduling complexities.

Pros: The concept's focus on utilising asynchronous socio-technical tools to support and mitigate issues caused by time-delayed communications aligns with the design goals of this research project.

Cons: The key aspects of this concept are tailored for situations with long-term communication restrictions and isolation issues. Fully recreating these issues for a prototype testing period would be problematic and likely futile, as it would not replicate the 'long-term' scenario. However, variants of this concept may find utility in more contemporary use cases.

4.1.5 Concept 5 - Digital Replicants

Context: The Digital Replicants concept arose from the hypothetical scenario of interplanetary living, where real-time communication disruptions can extend over prolonged periods. It leverages state-of-the-art technologies, including large-language data models and machine learning, to replicate the personalities and mannerisms of real friends or family members **(Fig 4.6)**. These replicas manifest as visible and audible personas through augmented reality, virtual reality, or holographic projection.

This concept represents a groundbreaking approach that harnesses advanced technologies like large-language data models, machine learning, augmented reality, virtual reality, and holographic projection to create highly realistic digital companions. These digital companions aim to bridge the gap for individuals experiencing social isolation due to interplanetary distances or other communication challenges that hinder direct interaction with loved ones.

Fig 4.6 - Concept visualisation of AI voice and image learning.

Concept Outline: The primary objective of this concept is to provide an innovative solution for individuals grappling with isolation, particularly those living on distant planets. This virtual companion serves as a surrogate for when direct communication is infeasible. The envisioned avatar is not only visually and audibly representative of the real person but is also endowed with the ability to simulate their mannerisms and personality, thereby enabling a sense of companionship during periods of communication disruption.

The digital avatar serves as a conduit for communication between isolated individuals and their real-world counterparts. Instead of reading text-based messages, recipients can interact with the avatar in a more natural and conversational manner, akin to a face-to-face conversation. Moreover, the avatar plays a pivotal role in bi-directional communication by relaying social content between the isolated individual and their contacts back on Earth. This buffer minimises the emotional impact of communication latency caused by interplanetary distances.

Variant - Virtual Pets

This variant builds upon this concept by exploring the creation of non-human avatars, such as virtual pets. These digital companions replicate the companionship and emotional support provided by real pets. In situations where real-world challenges hinder pet ownership, this variant offers a meaningful solution to combat loneliness.

Variant - Virtual Trainers

This variant introduces the concept of a virtual exercise trainer **(Fig 4.7)**. Individuals struggling with healthy habits can benefit from a virtual persona guiding them in exercise routines and healthier lifestyles. The interactive and communicative nature of this avatar promotes motivation, accountability, and the establishment of new routines.

Fig 4.7 - A concept render of an augmented reality or holographic physical trainer.

"I barely exercised during lockdown. I always found excuses. When I go to the gym with a friend they push me to actually exercise and get into a routine."

- Quote from participant #W034, proposing roles that virtual personas could perform.

Rationale: The "Digital Replicants" concept envisions a realm where advanced technologies converge to provide companionship and connection in situations characterised by social isolation. Through the creation of lifelike digital personas, this concept transcends social barriers and redefines communication dynamics, ultimately aiming to alleviate loneliness and foster well-being. Its adaptable variants further extend the concept's applicability, addressing diverse challenges from loneliness to physical fitness.

Pros: The concept explores intriguing possibilities by harnessing advanced and emerging technologies. The idea of supplementing or substituting traditional social interactions with virtual surrogates, though reminiscent of science fiction, holds promise, particularly in extreme cases of social isolation.

Cons: Like the "Synchroni-Link" concept, the implementation of any AI-based solution is currently infeasible. While a synthetic solution mimicking AI may be conceivable, the requirement for long-term and on-demand availability makes it impractical. Ethical concerns regarding the replication of individuals' voice and image data also present significant challenges beyond the scope of this study.

4.1.6 Workshop Concepts Summary

The workshops yielded a diverse array of HCI-based intervention concepts aimed at mitigating social isolation and communication disruptions across different scenarios. These concepts were inspired by real-world experiences and cutting-edge technological advancements. However, they also presented various challenges and limitations, particularly concerning feasibility within the confines of the research project.

The **Alone Together** concept, targeting social isolation among hospital patients, demonstrated the potential of technology to foster connections in healthcare settings.

Nevertheless, the necessity for hospital-based testing and ethical considerations surrounding patient participation presented practical hurdles.

Similarly, the **Synchroni-Link** concept, which sought to employ AI for facilitating spontaneous interactions among friends, faced challenges related to AI system development, ethics, and privacy concerns.

The **CPAP-VR** concept, leveraging VR technology to alleviate isolation in medical treatment scenarios, encountered obstacles due to the requirement for a hospital environment and specialised equipment for testing.

The **Digital Replicants** concept, proposing the creation of lifelike digital personas to bridge communication gaps, highlighted the potential of advanced technologies. However, the development of such sophisticated AI-based solutions and the evaluation of associated ethical issues fell beyond the scope of the research project.

While the AI-based concepts demonstrated innovation and potential, their technical complexity and high development costs rendered them unfeasible for this research project's scope. Additionally, concepts requiring long-term testing environments or testing in situations involving complex privacy and ethical factors posed challenges that couldn't be overcome within the project's constraints.

Consequently, in the upcoming design and development phases outlined in **Chapter** 5, the focus will shift towards deriving inspiration from concepts that can be feasibly transformed into demonstrable socio-technical intervention prototypes within the confines of the current research parameters. This strategic adjustment aims to ensure practicality and effectiveness in the subsequent stages of the research project.

4.2 Prototype Development

During the prototype development phase, the objective was to expand upon the concepts generated during the co-design workshops. The aim was to construct two prototypes - one synchronous and one asynchronous in design - that could be readily developed into demonstration models. These models were then tested among volunteer social groups. This

approach facilitated a comparative assessment of the effectiveness of these two approaches, while also exploring the broader efficacy of utilising socio-technical interventions to address the diverse preferences and challenges faced by individuals experiencing social isolation, as identified by the participants.

Taking into consideration the recommendations of Findlay (2003) and Cattan et al. (2005), which suggest that facilitating social interactions with multiple participants is more effective in enhancing social engagement and reducing loneliness, the selected prototypes prioritised group-based activities over one-to-one encounters.

Within this framework, elements were selected from the concepts outlined in **Section 4.1** to create two distinct prototype designs. Recognising the constraints and feasibility concerns associated with complex concepts such as AI-based designs, the research project shifted its focus toward more achievable solutions. These prototypes were developed by amalgamating and refining key features from the workshop concepts, with the aim of addressing challenges related to social isolation, communication disruption, and connection-building in practical ways. The subsequent sections provide details into the development of these prototypes, highlighting critical concepts and design considerations that guided their creation. To ensure the effectiveness and usability of these intervention prototypes, live-demonstration models were created. These models offer hands-on experience, allowing volunteers to fully engage with the interactive designs. The descriptions of these demonstration models, along with any design alterations and the rationale behind these choices, are provided in the respective prototypes' development sections.

Physical Prototypes and Demonstration Limitations: While the conceptual design goals of this project aimed to create physically tangible socio-technical interventions, the prototypes developed for demonstration and user testing are digitally based due to practical constraints. Producing physical prototypes would have been prohibitively time-consuming and costly. This decision allows for a more streamlined and accessible testing process. The final intervention design recommendations, outlined in **Chapter 6**, will include proposals for a physical presence in the user's space, serving as a prompt towards social engagement.

4.3 Prototype 1 - Social Circles

Outline: Social Circles is an interactive platform designed to facilitate regular social interactions. This tool caters to individuals dealing with social anxiety, those looking to improve social skills, and remote-working teams fostering consistent communication.

4.3.1 Key Features and Objectives

1. **Personalised Availability:** The platform revolves around user-defined "availability" statuses for social interactions, which can be easily managed through an intuitive interface. These statuses synchronise across all devices owned by members of the user's social network.

2. **Enhancing Social Engagements:** The primary goal of Social Circles is to increase the frequency and quality of social interactions within the user's social network.

3. **Combating Social Isolation:** By promoting effective social interactions, the tool aims to combat social isolation, providing a lifeline to individuals who may feel disconnected.

4. **Alleviating Communication Apprehension:** Social Circles offers a structured platform that can help individuals overcome communication apprehensions and build confidence in their social interactions.

5. **Strengthening Support Networks:** Through group-based social engagements, this tool encourages and maintains robust support networks among friends and colleagues. This aligns with the goals identified in existing literature for mitigating the effects of social isolation (Swickert *et al.*, 2002; Findlay, 2003; Cattan, White and Bond, 2005)

The Social Circles prototype aims to tackle social isolation by making social interactions more accessible, especially for individuals who may find initiating social engagement challenging. This section offers an in-depth overview of the prototype's development and functionality, including key design principles, the user experience, and anticipated benefits.

4.3.2 Foundation

This prototype draws its inspiration primarily from the discussions and framework of the Synchroni-Link workshop concept, as detailed in **section 4.1.2**. Its core objective aligns with the fundamental goal of the project: to mitigate social isolation by serving as a social engagement facilitator. However, it deviates from the original concept due to technology limitations. Unlike Synchroni-Link, this prototype does not incorporate AI automation to analyse users' ongoing activities or trigger social connections. Instead, it relies on a manual process, focusing solely on facilitating and creating awareness during social interactions.

4.3.3 Design Evolution

The initial concept for this prototype centred around the idea of small light-up 'avatar' dolls, each engraved with the name of a member of the social network they represented **(Fig 4.8)**. These dolls were envisioned as incorporating touch-based capacitive technology, making interactions as simple as a tap of a finger. For instance, tapping one's own doll avatar would change its colour, with continuous taps cycling through a series of colours. Each colour was intended to convey specific meanings, such as white for "Standby" (the default), blue for "Available" (indicating readiness for social interaction), and red for "Do not disturb."

Fig 4.8 - A graphical representation of the 'avatar' dolls concept

However, this design, while compact (around 80mm tall), had limitations in terms of space utilisation and the accommodation of larger social groups. The use of colours to convey availability also posed challenges in representing a wider range of distinct states, potentially causing user confusion. As a result, the design underwent a significant overhaul, drawing inspiration from touch-based physical design items like the digital 'Smart Mirror' and the 'Stream Deck' customisable control interface. The revised design incorporated an array of small OLED (Organic Light-Emitting Diode) based screens enclosed within circular housings, with a central screen mounted on a rotary dial or switch **(Fig 4.9)**. Each circle was associated with a specific member of the social group, and the central circle represented the user. Users could select their current availability by rotating their central dial, cycling through assorted options:

White Circle: Standby. Default, no specific attribute.

Green Thumbs-Up: Available for general social engagement

Red Exclamation: Do Not Disturb. Prevents inclusion in any activities

Blue Hot Drink: Tea/Coffee Break. Indicates a short availability window

Fig 4.9 - The redesigned physical prototype variant for 'Social Circles'

The 'tea break' option was added due to additional feedback from workshop interview participants, who suggested that it could emulate the common 'housemates' gathering for a chat over a cup of tea, a tradition disrupted when people no longer shared residences.

When a user adjusts their central control dial to select availability options, the choice propagates to the user's associated icon on every other device in the network, prompting other available users to initiate social engagement. The use of small OLED screens allowed for a more detailed availability alert system, replacing limited colour values with easily interpretable icons, enhancing user experience and comprehension.

4.3.4 Demonstration Prototype

To facilitate alpha-stage prototype testing, the design deviated from the original physical prototypes, with OLED screens and independent Wi-Fi capable controllers, because they would have been prohibitively complex and expensive for the study's purposes. Instead, the core functionality and concept were adapted into a mobile app developed using the ReactJS Framework for Android, allowing for distribution to a wider testing audience for minimal cost. To share updated data states among participants, secure real-time online databases were utilised using the Firebase cloud computing service.
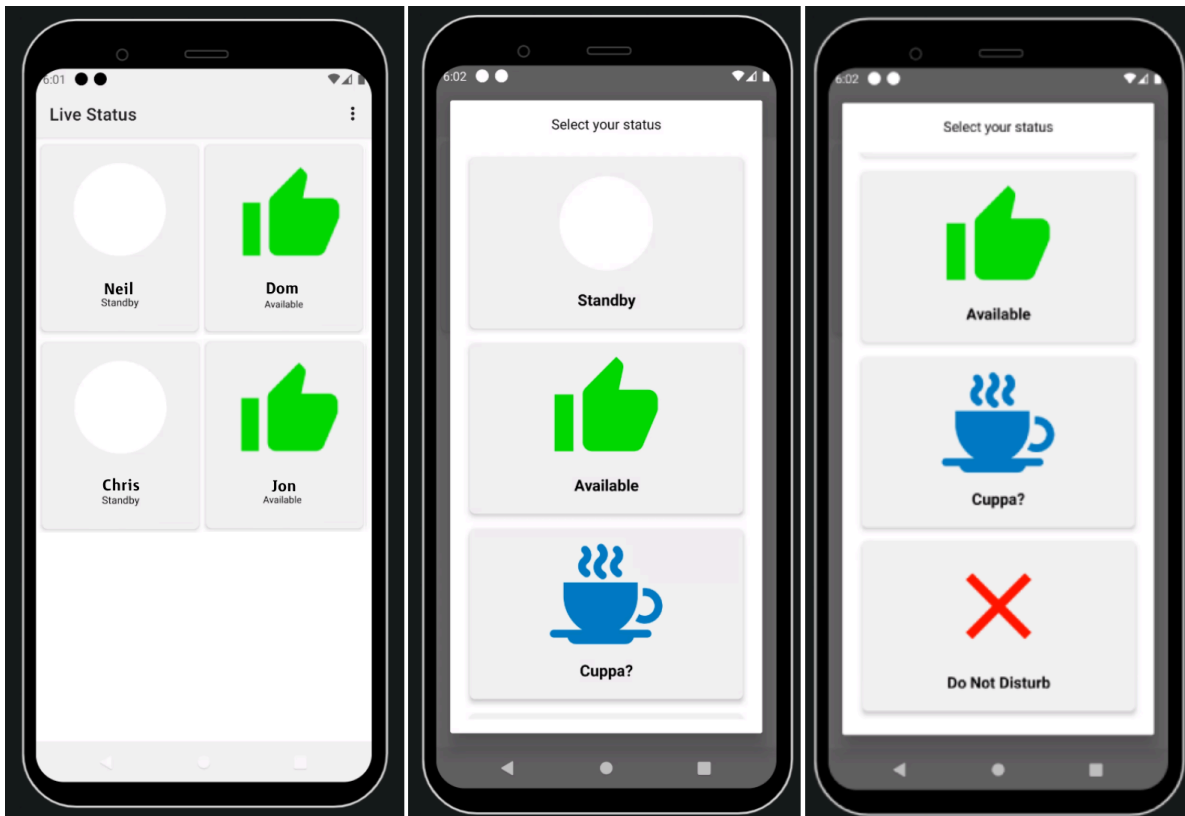
Fig 4.10 - Example panels of the Social Circles prototype android app.

When a participant logs into the application, they can view the status of all members in their participating social group, as depicted in the first panel of **Fig 4.10**. The status cards display the name of the participant and their current availability status. The first card always represents the user themselves, as shown in the example with "Neil." Tapping on their card opens a status selection screen, as seen in the second and third panels of **Fig 4.10**, allowing the user to scroll through available options and select one with another tap.

Once a status is selected, the new icon and status description appear on the user's card, and this information is propagated to every other user through the cloud-based database. Each user receives a push notification following their device's notification rules. In the first panel of **Fig 4.11**, the example shows that the user "Neil" has selected the "Cuppa?" status, and a notification shade popup appears at the top of their screen to indicate an update. In the third panel of **Fig 4.11**, the example demonstrates that this notification is also displayed in the notification area of the Android operating system. However, the behaviour of notifications can vary depending on user settings and preferences.
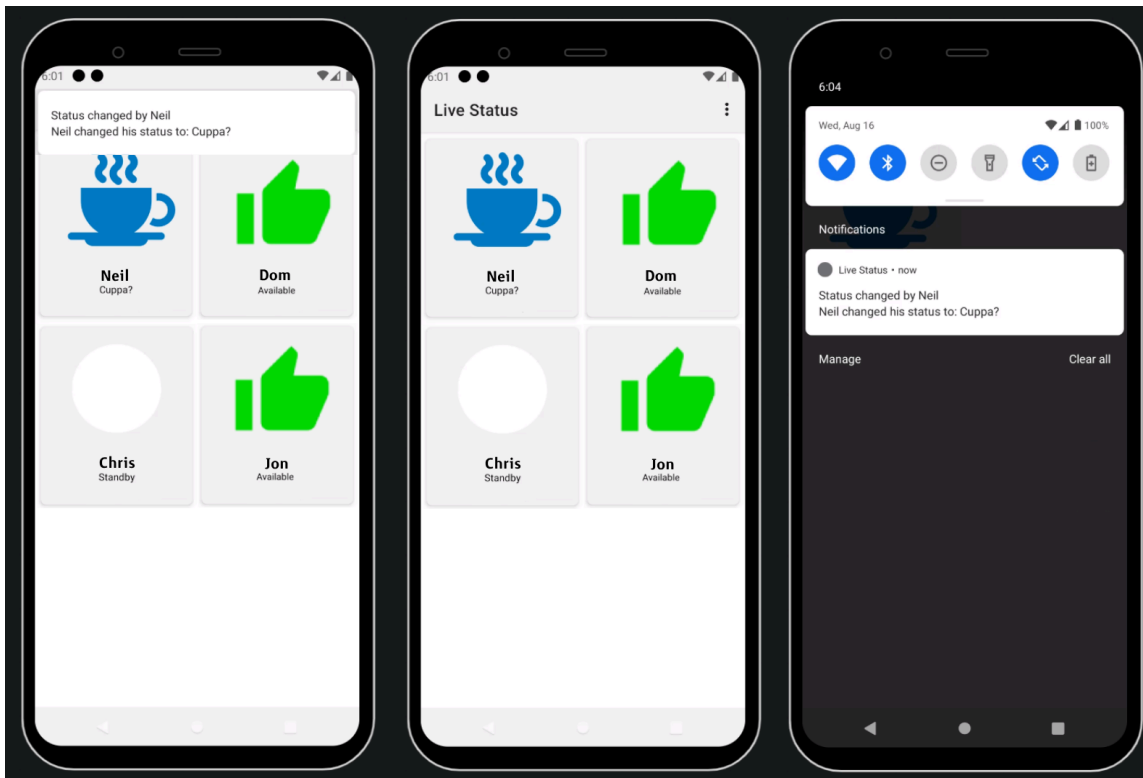
Fig 4.11 - Example panels of the Social Circles prototype android app.

4.4 Prototype 2 - Syncboard

Outline: The Syncboard design is a dynamic digital canvas aimed at nurturing creative connections within social groups by offering a unique form of asynchronous communication. This versatile platform empowers users to express themselves through various mediums, providing a therapeutic creative outlet.

4.4.1 Key Features and Objectives

1. **Dynamic Collaboration:** Syncboard goes beyond being a simple communication tool; it serves as a collaborative space where users can engage in creative exchanges, share heartfelt messages, and craft visual stories together.

2. **Multi-Modal Expression:** This platform transforms communication into a dynamic visual experience, enabling individuals to convey their thoughts, emotions, and ideas through a variety of creative modes.

3. **Meaningful Connections:** By merging community-based collaboration and creative expression, Syncboard aligns with research findings that underscore the effectiveness of such interventions (Cattan et al. 2005; Goncarlo et al., 2021).

4.3.2 Foundation

The foundation of Syncboard prototype is rooted in established research highlighting the significance of community-based collaboration and creative expression as effective interventions against social isolation (Goncarlo *et al.*, 2021). This prototype draws inspiration primarily from the "Messages in a Bottle" workshop concept, outlined in **section 4.1.4**. It takes cues from the sections of that concept related to the use of digital tools for novel asynchronous communication, along with incorporating ideas from the 'Collaborative Creativity' variant **(4.1.4)**. This design emphasises the use of graphics-based asynchronous connections, enabling communication and creative outlets.

This revised prototype retains its original functionality as an asynchronous communication tool, while offering solutions for social isolation issues caused by boredom and monotony.

4.3.3 Design Evolution

The initial design concept for Syncboard was that of a wall-hanging whiteboard, featuring an LED touch-screen panel with a screen size of approximately 30 - 45cm measured diagonally. This size was chosen to strike a balance between visibility when mounted on a room wall and usability when used handheld or placed on a table for extended writing or drawing sessions **(Fig 4.12)**.

Fig 4.12 - Early design iteration of the Syncboard prototype.

The first iteration of the design aimed to keep the interface simple and recognisable, resembling a standard whiteboard or corkboard commonly found in kitchens and study areas. The complexity was intended to be hidden behind the scenes, with each Syncboard canvas automatically synchronised across the social group **(Fig 4.13)**.
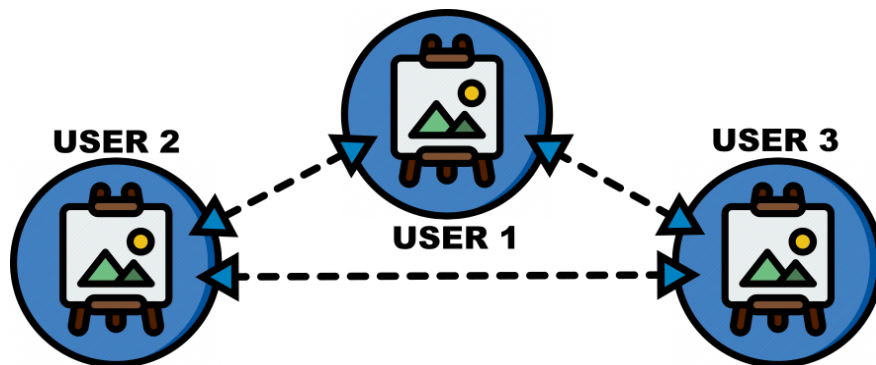
Fig 4.13 - A diagram showing the synchronisation of multiple Syncboard canvases.

However, an issue emerged as the shared canvas could quickly become filled with content. While users had the ability to delete sections of the canvas, this posed a problem for an asynchronous intervention like Syncboard where users might be minutes or hours behind in catching up with updates. Deleting messages or drawings before all users had a chance to view and interact with them would be counterproductive. Solutions for this issue included

automatic storage of 'snapshots' of the canvas, so that they could be reviewed by users at a later time.

4.3.4 Demonstration Prototype

Like the approach taken with the Social Circles design concept, creating a fully functional physical device for Syncboard would have been impractical due to the complexity and cost involved. Therefore, a solution was devised that leveraged users' existing touchscreen-based devices.
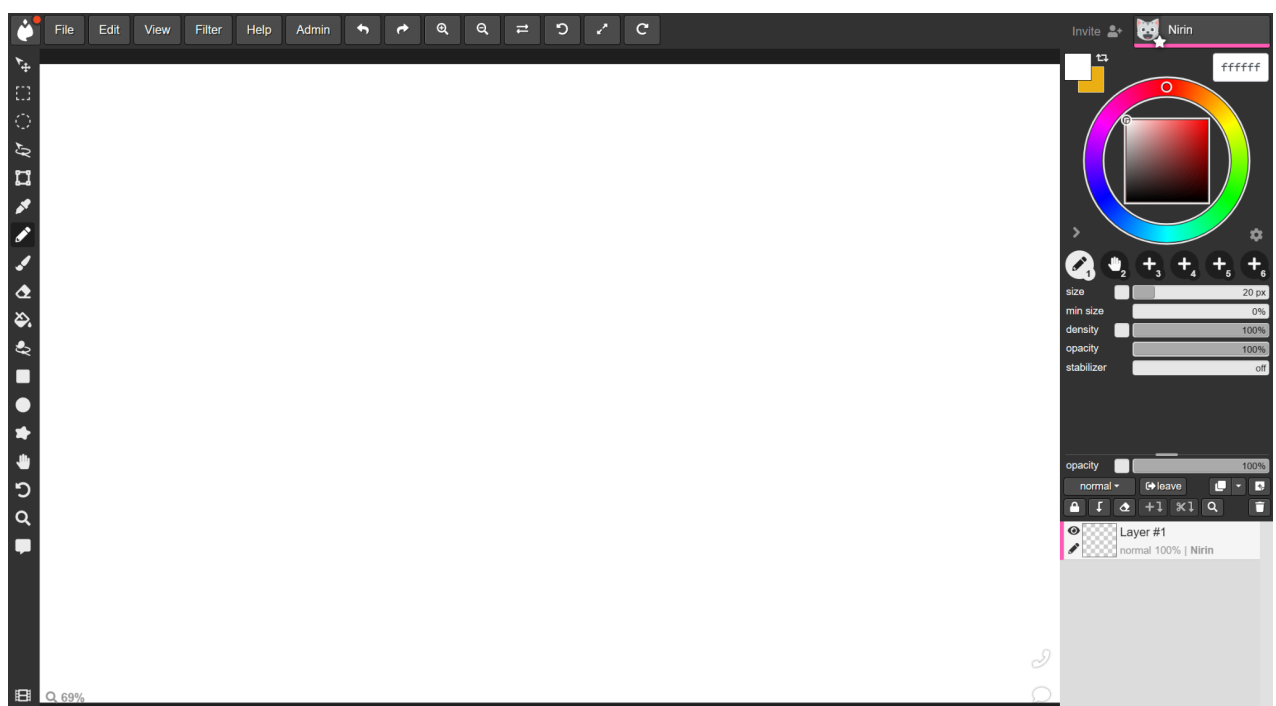
Fig 4.14 - A screenshot of the Magma browser-based digital art platform.

Magma, an existing browser-based digital art tool, was chosen for the prototype as it had similar functionalities to other digital art tools like Adobe Photoshop and Autodesk Sketchbook **(Fig 4.14)**. The Magma platform allowed for the replication of the whiteboard aspects of the Syncboard design, albeit with an unnecessary level of additional complexity. Users familiar with existing tools like Photoshop would have a relatively easy learning curve, but those unfamiliar with such programs might find the array of available options and drawing tools in the user interface challenging. To help address this, basic workflow instructions were provided to testing participants who required or requested them.

What made Magma particularly suitable for this project was its capability for multiple users to log in to a shared canvas and interact with it simultaneously **(Fig 4.15)**. Unfortunately, it was not possible to automate the snapshot and storage process of canvases using Magma. Instead, participant groups were instructed to manually create a new blank canvas whenever the current canvas became full. Each filled canvas was saved and stored by the Magma platform, so that both users and the researcher could revisit them at their convenience, with no risk of data loss.
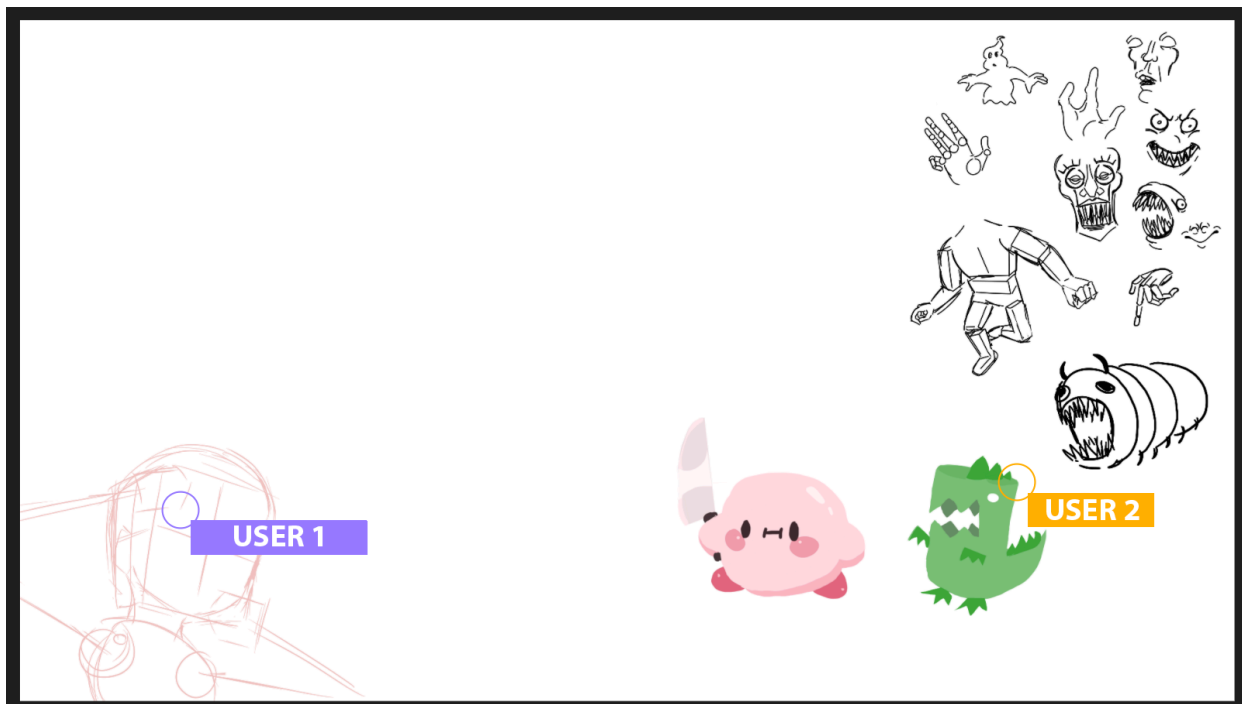
Fig 4.15 - Example of the Magma platform in use during prototype testing. Image shows multiple users interacting with the demonstration simultaneously.

4.5 Prototype Creation Summary

These alpha-stage prototypes were developed with the aim of demonstrating as many of the core principles of the two designs as possible. The goal was to allow test-case participants to utilise, test, and evaluate the designs comprehensively, providing valuable qualitative and quantitative testing data along with feedback on the prototypes.

Key Takeaways:

1. **Co-Design Approach:** The design and development process is informed by the collective wisdom and experiences of workshop participants, ensuring that the prototypes directly address their needs and challenges.

2. **Holistic Design:** Intervention prototypes are grounded in the multifaceted nature of social isolation, spanning diverse themes such as maintaining basic needs, managing emotions, and fostering connections.

3. **User-Centric Iteration:** The iterative testing process, involving volunteers, fosters a user-centric approach, allowing for real-time adjustments and enhancements based on user feedback.

4. **Innovative Solutions:** The HCI-based intervention prototypes aim to leverage technology creatively, providing both synchronous and asynchronous avenues for combating social isolation.

5. **Evidence-Based Design:** The prototypes draw inspiration from evidence-based research, aligning with the findings of the data analysis and intervention categories explored in previous chapters.

In the subsequent sections of this chapter, I delve into the practical testing phase, where these intervention demonstrations are put to the test with groups of volunteers. The insights gained from this testing phase will serve as a critical bridge between theory and practice, further refining the understanding of effective interventions for addressing social isolation.

Chapter 5. Prototype Testing

In this chapter, the prototypes developed in **Chapter 4** underwent a comprehensive user-centric testing procedure. The objective was to collect both objective data regarding the impact of each design, and subjective data encompassing user experiences, perceptions, and feedback on each prototype. The overarching aim was to compare synchronous and asynchronous solutions, while assessing the overall potential of socio-technical interventions in mitigating the challenges of social isolation. This chapter provided a detailed account of the methodology used for prototype testing, along with a thorough analysis and evaluation of the quantitative and qualitative data obtained throughout this process.

5.1 Prototype Testing Methodology

5.1.1 Testing Design

The prototype testing phase used a mixed research methodology, combining qualitative and quantitative data collection methods. When analysing participants' social connectedness during prototype testing, two recognised categories of social isolation were utilised - 'objective isolation', measured quantitatively, and 'subjective isolation', measured qualitatively (Pettigrew *et al.*, 2014). Objective isolation metrics can be tracked effectively using established quantitative scales like the Lubben Social Network Scale (Lubben, 1984) and the Patient-Reported Outcomes Measurement Information System (PROMIS) questions that apply to social isolation and loneliness (Cella et al., 2010). The synergistic use of these methodologies aimed to ensure a comprehensive assessment of the prototypes' effectiveness and paved the way for well-informed conclusions and recommendations.

Quantitative Data: This study collected and statistically analysed social metrics covering engagement frequency and social satisfaction, used as indications of loneliness. Established social research measurement tools were used to guide the questions used for this assessment, facilitating an objective comparative analysis between the prototypes.

1. **PROMIS Social Isolation Scale** - A measurement tool that uses patient outcomes to measure a variety of categories, such as pain, fatigue, emotional distress, and social role participation. Used to examine metrics that have a major impact on quality-of-life. (Cella et al., 2010).

2. **Lubben Social Network Scale** - A brief measurement tool designed to gauge social isolation in older adults by measuring perceived social support received by family and friends (Lubben, 1984).

3. **NIH Social Relationship Scale** - The 'National Institutes of Health' Social Relationship Scale were developed and tested in order to assess the impact of social relationships on health outcomes over time (Cyranowski et al., 2013).

Qualitative Data: This approach delved into personal perspectives, subjective experiences, emotional and psychological responses, and gathered feedback on design and functionality. These discussions subsequently facilitated iterative improvements and theoretical refinements for future recommendations.

Testing Preparation:
Social Circles:

In advance of the testing period for the Social Circles design, participants were each sent a copy of the Android Package Kit (.APK) file that contained the application installation data, along with instructions on how to install the app on their mobile device. Each participant was also given a brief tutorial on how to set up a personal log-in to the application and an overview of how the design is used.

Syncboard:

In advance of the testing period for the Syncboard design, participants were directed to the Magma website to set up their account. Users were given the option of signing up via an

email address of their choosing or via social media logins, depending upon personal preferences. Users were also given the option of a tutorial overview of the various available tools and functions of the application upon request.

5.1.2 Participants

In this study, a total of forty participants were involved, organised into social groups consisting of three to five individuals. The grouping of participants was determined by self-selection rather than strategic allocation due to the social nature of the project. While this approach lacks true randomisation and demographic balancing, it was chosen to align with the social dynamics of the prototypes being tested. Prior to participating, all individuals received information about the testing procedures, the expected duration of testing, and the requirements for their involvement. Here is a breakdown of the participant demographics:

Age Range: Participants' ages varied from 18 to 60.

Gender Distribution: There were 26 males and 14 females among the participants.

Personality Types: Participants were self-identified as 20 introverts and 20 extroverts.

Recruitment: All participants were recruited through social media channels or social groups.

Geographic Location: All participants reside in the United Kingdom.

5.1.3 Locality

Due to constraints related to the researcher's health, in-person monitored testing scenarios were not feasible for the prototype testing. Instead, the groups were provided access to the demonstration prototypes on their devices at home. Synchronisation among members of the social groups was facilitated through cloud-based database services - for Social Circles, this was facilitated via the Firebase development platform, and for Syncboard this was built into the Magma platform. This approach allowed for an extended utilisation of the tools over a duration that exceeded what could have been achieved with in-person monitored testing.

5.1.4 Data Gathering

The key aims for the data gathered from these methods were:

1. **Social Engagement:** Assess the frequency of participants' active involvement in social activities facilitated by the prototypes.

2. **Social Satisfaction:** Measure the quality of participants' social experiences and its relationship to the prototypes.

3. **Loneliness Levels:** Evaluate changes in participants' subjective loneliness before and after using the prototypes.

4. **Emotional and mental well-being:** Examine subjective changes in emotional well-being and stress levels due to reduced social isolation.

5. **Reflections and Feedback:** Gather qualitative insights on individual experiences, challenges, and recommendations.

During the prototype testing phase, data collection was carried out through a combination of questionnaires and interviews. This method was strategically designed to provide insights into both objective and subjective aspects of social isolation (Pettigrew *et al.*, 2014).

To assess the quantitative aspects, specialised scales were developed by incorporating questions from established measures such as the Lubben Social Network Scale, the NIH Social Relationship Scale, and the PROMIS Social Isolation Scale (Cella et al., 2010; Lubben, 1984; Cyranowski et al, 2013). This allowed structured data for objective analysis to be gathered.

For the qualitative aspects, interviews were conducted to delve into participants' subjective experiences and perceptions, providing a richer understanding of their interactions with the prototypes. This dual approach ensured a holistic assessment of the interventions' impact on social isolation.

The questionnaires were administered at four pivotal stages of the testing:

1. **Pre-Testing:** Gathering baseline data before any testing took place.

2. **Post-Testing** of the first design.

3. **Post-Testing** of the second design.

4. **Post-Testing Follow-Up:** Gathering data 1 month after testing ended.

Post-testing interviews were used to discuss the testing experience, and gather qualitative data on reflections, feedback and recommendations regarding issues or refinements - data that was used to inform on the benefits or limitations of the prototypes, and the recommendations for development of future iterations. This hybrid data collection approach aimed to provide both statistical comparisons of intervention effectiveness and subjective insights into participant experiences and emotions.

5.1.5 Data Handling

Due to the nature of the research, only limited non-identifiable information from the participants was required, and only after written consent was given by them. This information includes:

- Pre- and post-experiment questionnaires regarding social interactions, social history, and mood.
- Questionnaires will include sections where participants can feedback on the design, highlight issues, and propose improvements.
- Audio recordings of post-testing interviews, used for later transcription and analysis.

All information is kept strictly confidential. Any quotations from participants which are included in this thesis have been anonymised. All visualised or recorded feedback has also been anonymised. The collected anonymised data could be used for publication or conference purposes, which was made clear on the consent form and participants were aware that their ideas and discussions may be used for further development.

Any data used as part of the research has been anonymised. Raw data has been stored on the private and secure university OneDrive server, accessible only by the research team (Microsoft Corporation, 2023). While the raw data is stored on the university server, in the unlikely event of a breach where participants' data is leaked, all participants will be informed as well as the University's Data security officer. The raw data will never leave the secured server environment.

Data from the design testing does not have any names or identifying labelling attached. Any experiences or ideas which may allow the participant to be identifiable has been obfuscated. All these data have been anonymised using participant identifier codes. Any quotations from the study which are published will be anonymised to ensure confidentiality. This information was also provided in the consent forms and participant information sheets.

All data is kept on the secure university servers for at least 12 months after having been recorded, in order for it to be available for analysis and future publications. Once all research outputs have been completed, the data will be securely destroyed (up to 5 years).

5.1.6 Testing Workflow

The prototype testing was undertaken across two planned testing phases **(Fig 5.1)**, involving ten distinct participant groups, with the aim of testing two different prototype designs. To ensure a balanced and controlled approach, the participant groups were anonymously numbered and then evenly divided into two sections - 'odd-numbered' and 'even-numbered.' The odd-numbered groups began by testing the Social Circles prototype first, while the even-numbered groups began their testing with Syncboard. This methodological division allowed for systematic comparison and evaluation of both prototypes, while mitigating any potential bias that could arise from the order of testing. Questions evaluating social engagement and social satisfaction were applied before testing began, and after this first phase of testing, to gather quantifiable data on the mitigation effects of each design.

After the first phase of testing was complete, and a short intermission period of five to seven days - slight variance dependent upon participant scheduling - the groups began the second phase of testing on the opposite prototype to the one they tested in phase one. After this secondary testing phase, the questionnaires were applied once more.

After testing was completed, and a one-month intermission, a fourth and final round of questionnaires were applied to determine how engagement and satisfaction metrics were affected after a period without supplementary interventions. During this time, follow up

one-to-one interviews were also conducted to gather reflections and discussions on the prototype designs and testing procedures and outcomes.
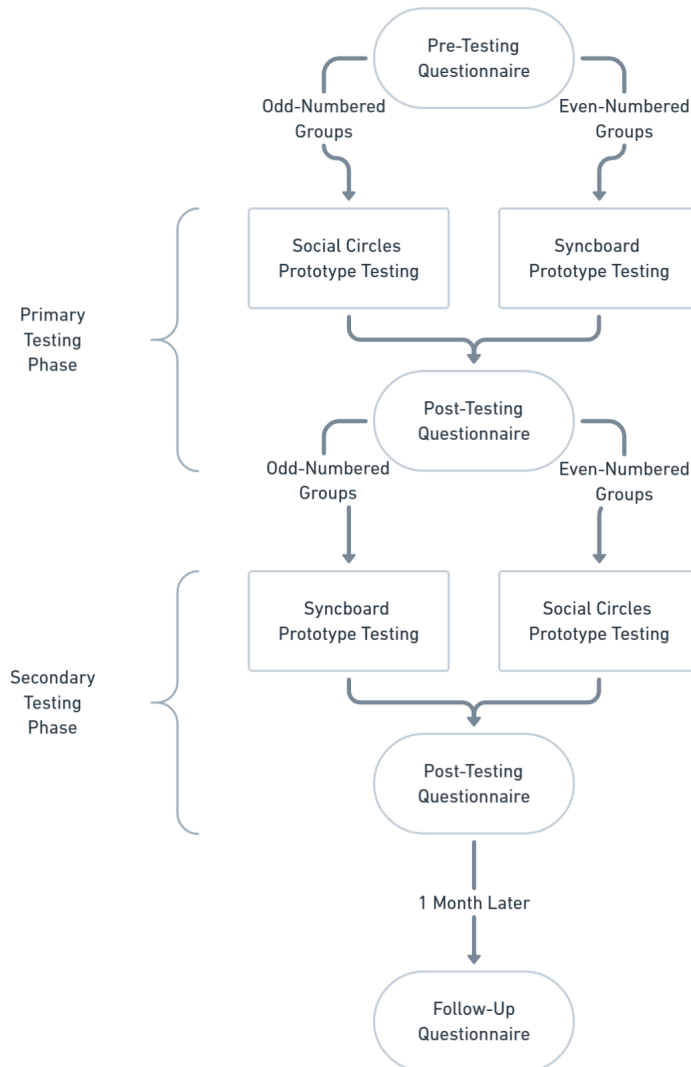
Fig 5.1 - Flow diagram of the prototype testing procedure.

A limitation of this method of testing is that the quantitative data gathered during the second phase of testing may be affected to an unknown degree by any lingering mitigations or effects that the participants experience from utilising the first phase design. However, it may be possible to use the analysis of data gathered from this methodology to determine limited comparisons between each design concept, along with learning if there are any significant benefits or issues that come with combining the two unique design approaches. While the secondary phase of testing may not be as valuable as the primary phase with regards to the quantitative data, this methodology allowed for a wider variety of participants to experience

both designs, providing a richer array of subjective data and feedback resources to draw from for the final analysis.

5.2 Prototype Testing Questionnaire Analysis

To establish measurements of social metrics among the testing participants, a questionnaire was administered that aimed to assess the social engagement and satisfaction experienced by individuals undergoing testing. Responses were then collected and normalised to create overall ratings for social engagement and satisfaction. These ratings ranged from 0 to 100, where a score of 0 indicated a complete lack of engagement or satisfaction - also indicative of extreme loneliness - while scores of 100 represented maximum engagement or satisfaction. This allowed for an objective quantitative assessment of participants' social well-being.

5.2.1 Broad Analysis - General Effectiveness of HCI Interventions

The data was analysed to examine the overall changes in social engagement and social satisfaction scores throughout the testing period:

- **Pre-Testing:** Data collected before any testing took place.

- **Post-Testing:** This analysis combined results from both the primary and secondary post-testing phases to provide an approximate average result of the overall benefit of using socio-technical interventions, regardless of the specific intervention.

- **Follow-Up:** Data from questionnaires given one month after testing was completed.
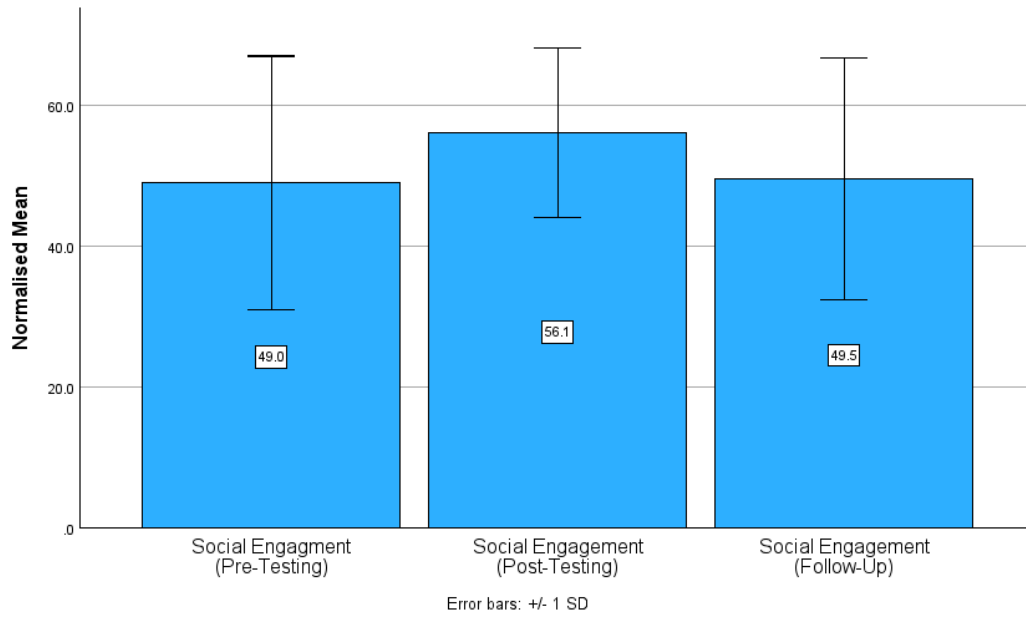
Fig 5.2 - Chart and associated data table showing broad social engagement metrics.
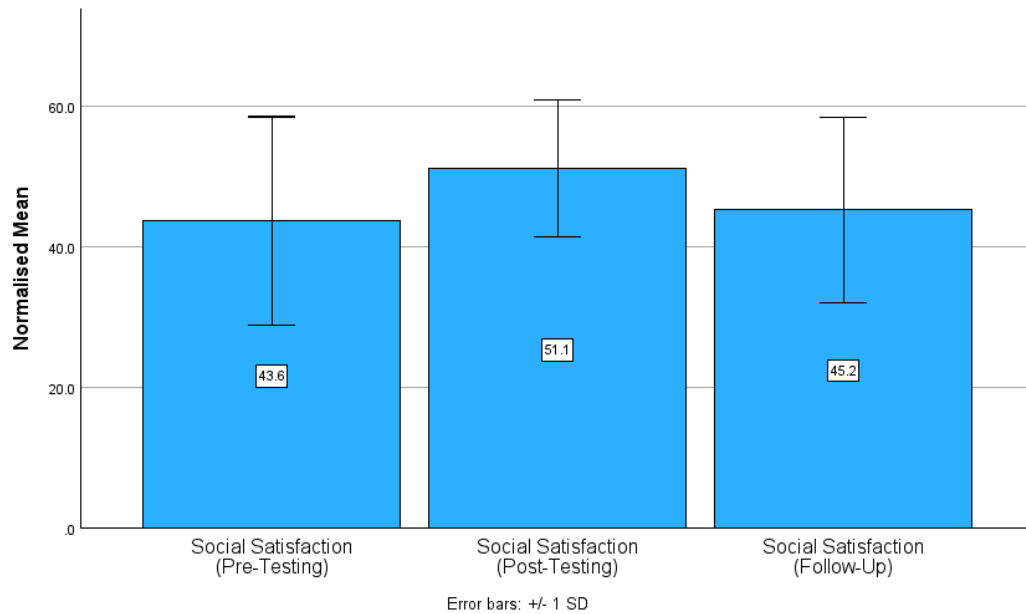
Fig 5.3 - Chart and associated data table showing broad social satisfaction metrics.

The average (mean) level of social engagement across all forty participants increased from a mean of 49.0 (SD=18.0) before testing to 56.1 (SD=12.0) after testing. Engagement fell to near baseline levels after the one-month follow-up period (M= 49.5 SD=17.1) **(Fig 5.2)**.

Similarly, social satisfaction across all participants increased from a mean of 43.6 (SD=14.8) before testing to 51.1 (SD=9.7) after testing. Satisfaction levels fell back to near baseline levels after the one-month follow-up period (M=45.2 SD=13.2) **(see Fig 5.3)**.

These improvements in social engagement (7.1 ± 1.2, t(39)=5.9, p=<0.001) and social satisfaction (7.5 ± 1.4, t(39)=5.3, p=<0.001) support the hypothesis that socio-technical interventions can provide significant mitigation effects on factors causing loneliness.

5.2.2 Primary Prototype Testing Phase

For the primary prototype testing phase, groups were evenly split between testing the Social Circles and Syncboard prototypes. Questionnaires were conducted after a week of testing.

Fig 5.4 - Chart showing mean change in engagement and satisfaction for users testing Social Circles
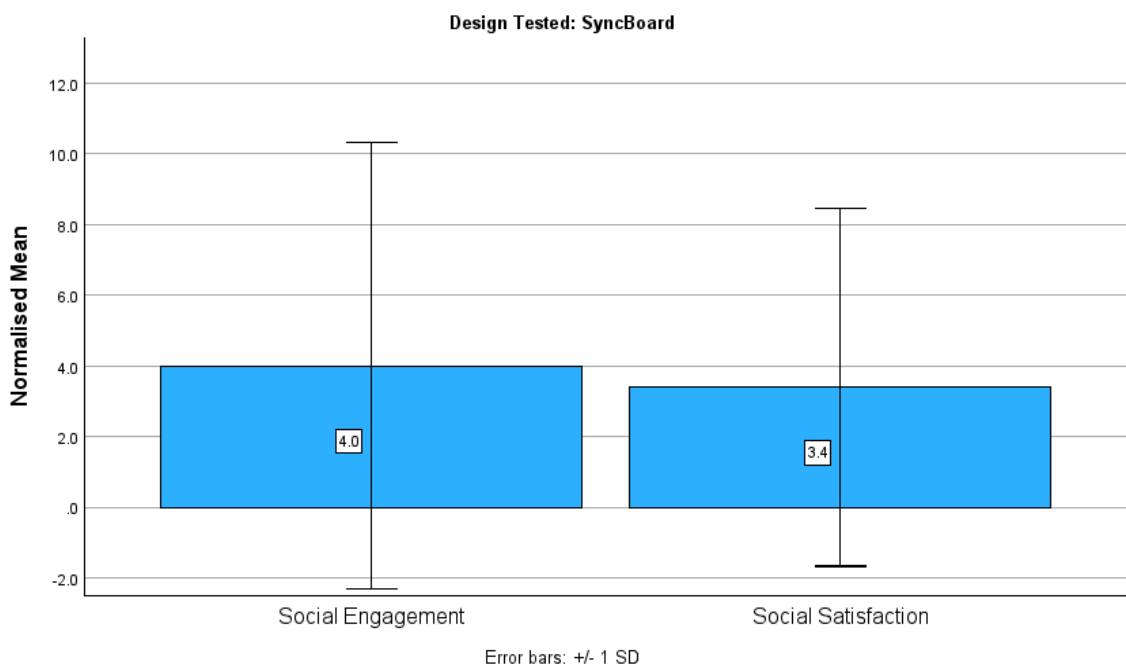
Fig 5.5 - Chart showing mean change in engagement and satisfaction for users testing Syncboard.

Comparing the **social engagement** scores for participants using the Social Circles prototype (6.8 ± 6.4, t(19)=4.7, p=<0.001) and the Syncboard prototype (4.0 ± 6.3, t(19)=2.8, p=0.011), it appears that both prototypes led to statistically significant improvements **(Figs 5.4 & 5.5)**. However, the Social Circles intervention showed a significantly greater degree of improvement in social engagement.

A similar trend is observed when comparing **social satisfaction** improvements for participants using the Social Circles (7.3 ± 7.6, t(19)=4.3, p=<0.001) and Syncboard (3.4 ± 5.1, t(19)=3.0, p=0.007). Again, both designs showed statistically significant improvements, with Social Circles once more displaying the greater improvement **(Figs 5.4 & 5.5)**.

These results suggest that the Social Circles design may be the more effective option for improving the frequency and quality of social activity. Syncboard, while still facilitating significant improvements in both metrics, does not seem to be as effective overall when directly compared to Social Circles. Further analysis to determine why this is the case will be an important future step, along with discussions with the users to determine if non-quantitative factors also benefit one design over the other.

The large standard deviations in the results suggest that there is significant variability among participants. This variability will be further analysed in later sections to determine if it is due to normal individual differences or there is a correlation with other factors.

5.2.3 Secondary Prototype Testing Phase

During the secondary prototype testing phase, participants are switched to the opposite prototype from the primary phase. These results are not compared against the original baseline figures, but instead against the results from the primary testing phase. This allows for an assessment of whether the secondary prototype provides additional benefits or has a deleterious effect on social metrics.

When comparing post-testing **social engagement** results for participants testing Social Circles (3.5 ± 5.1, t(19)=3.1, p=0.006) and Syncboard (-0.1 ± 2.3, t(19)=-0.2, p=0.853) in the secondary testing phase, only Social Circles continues to show a significant improvement.
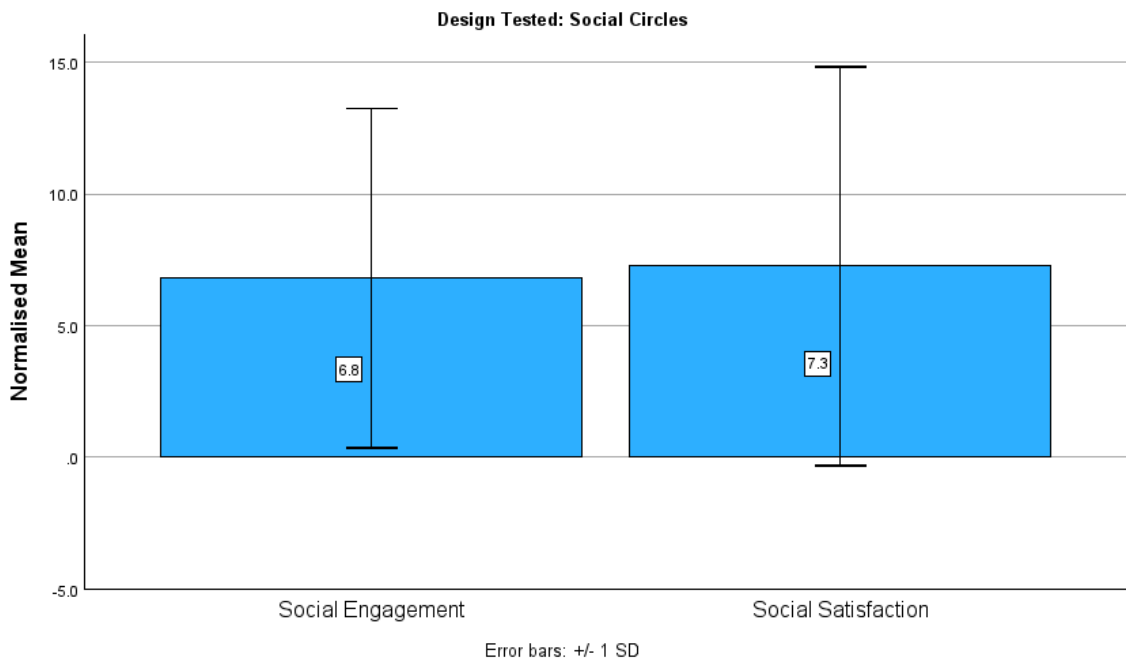
Fig 5.6 - Chart showing mean change in engagement and satisfaction for users testing Social Circles
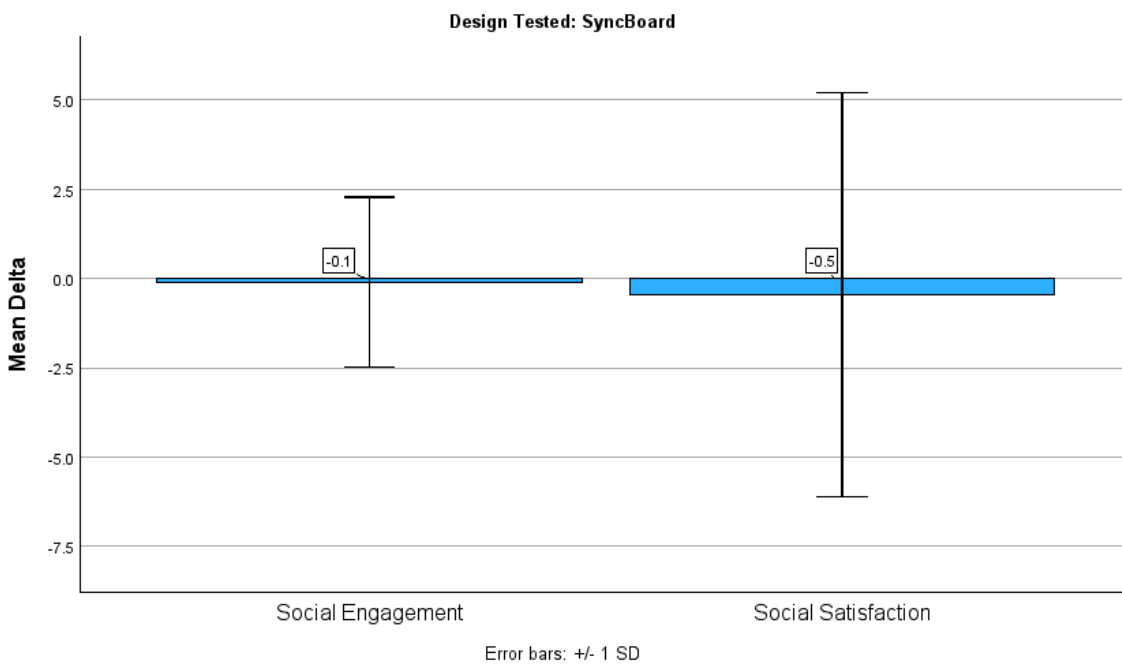
Fig 5.7 - Chart showing mean change in engagement and satisfaction for users testing Syncboard.

Similarly, in the comparison of social satisfaction between Social Circles (4.5 ± 6.7, t(19)=3.0, p=0.007) and Syncboard (-0.5 ± 5.7, t(19)=-0.4, p=0.716) for the secondary phase, only Social Circles demonstrates any significant improvements **(Figs 5.6 & 5.7)**.

These results indicate that use of the Social Circles design, even after individuals had already utilised the Syncboard intervention, provided significant additional benefits at

mitigating isolation and loneliness. This contrasts with participants switching to Syncboard after using the Social Circles prototype, where there were no significant changes - positive or negative - to levels of engagement and satisfaction. This outcome suggests that the Syncboard design has few additional benefits compared to Social Circles. However, Syncboard may be sufficient for staving off the effects of loneliness during times when Social Circles cannot be utilised, and it may also have other beneficial purposes that are not apparent from the quantitative data. This aspect will be further explored in the more subjective data gathering later in this chapter.

Once again, these results show large standard deviations, indicating that several participants exhibited changes that deviated significantly from the mean. Exploration of a potential cause for this variability will be examined in the next section of this analysis.

5.2.4 Introverts vs Extroverts

Due to the limited pool of subjects, only certain metrics could be analysed to a sufficient degree to draw conclusions as to the potential reasons for the variance in standard deviation. The three demographic variables available from the collected data that may have caused this were age, gender, and personality type - introverted vs. extroverted. While gender was quickly discounted, having shown no significant impact on the efficacy of social interventions, the age of participants could not be sufficiently analysed due to the limited participant pool. However, personality type could be examined **(Fig 5.8)**.

Report

Personality Type		Social Engagment (Pre-Testing)	Social Satisfaction (Pre-Testing)
Extrovert	Mean	63.3	55.0
	Std. Deviation	10.4	5.3
Introvert	Mean	34.6	32.3
	Std. Deviation	11.1	12.3

Fig 5.8 - A report of pre-testing values for engagement and satisfaction by personality type.

The pre-testing questionnaire results revealed significant differences in mean scores, where extroverts exhibited higher scores for both engagement (M=63.3 SD=10.4)) and satisfaction (M=55.0 SD=5.3), compared to introverts' engagement (M=34.6 SD=11.1) and satisfaction

(M=32.3 SD=12.3). These scores indicate that introverted participants generally had lower baseline social metrics, and therefore higher levels of loneliness and isolation. These results provide valuable baseline data, serving as a reference point for evaluating the specific benefits each intervention design may have had on participants of each personality type.

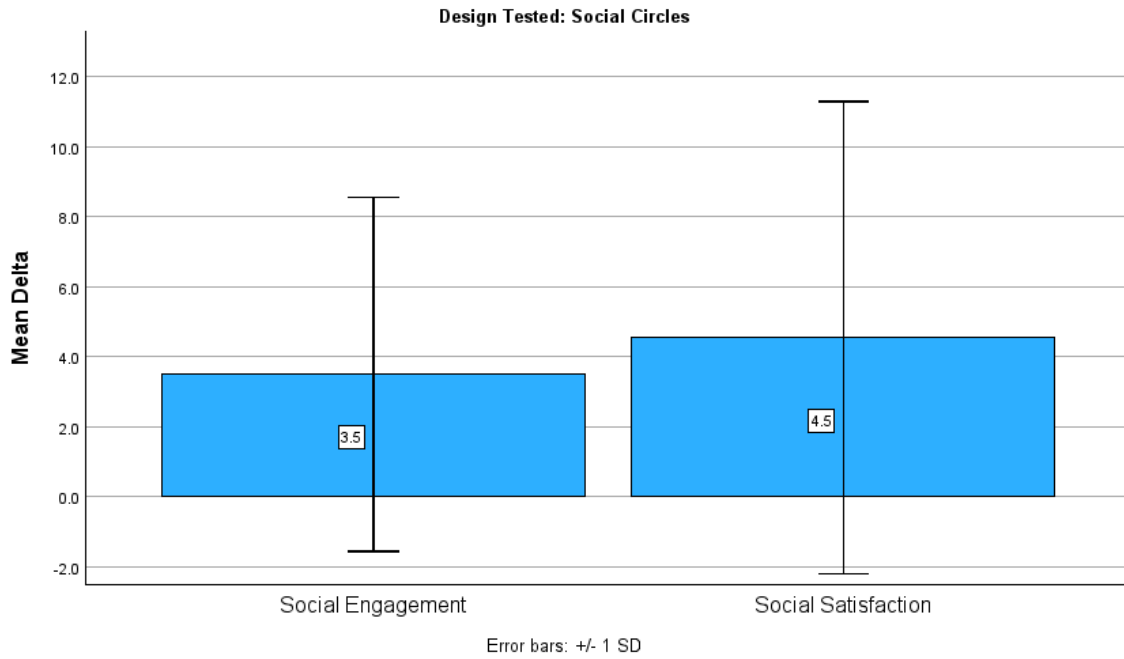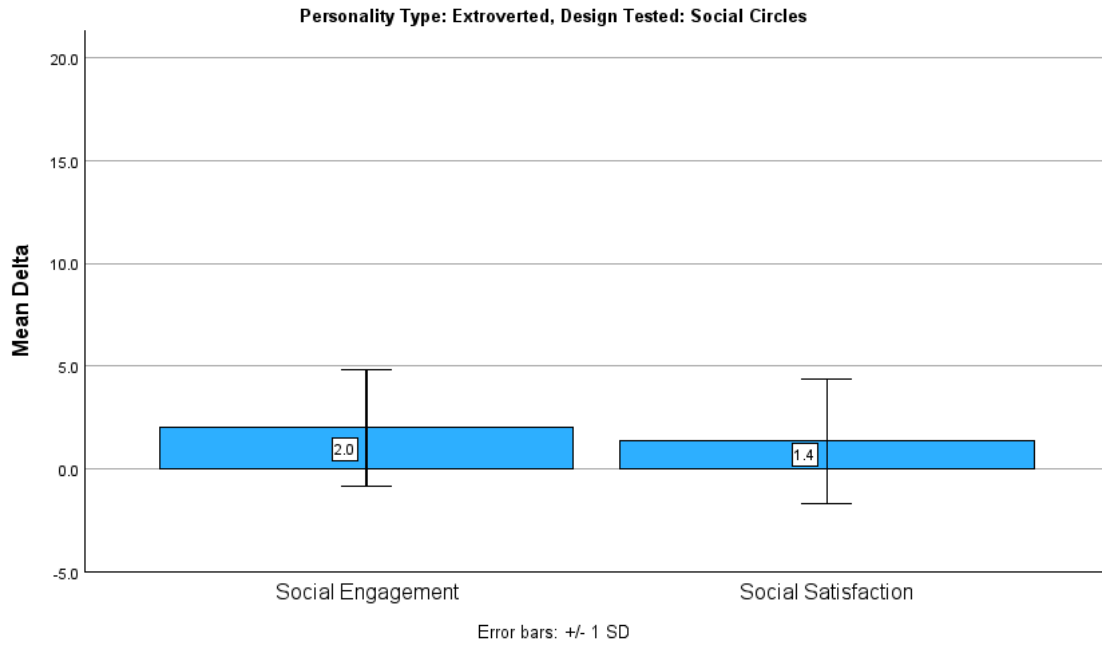Fig 5.9 - Chart showing mean delta engagement and satisfaction for extroverts testing Social Circles.
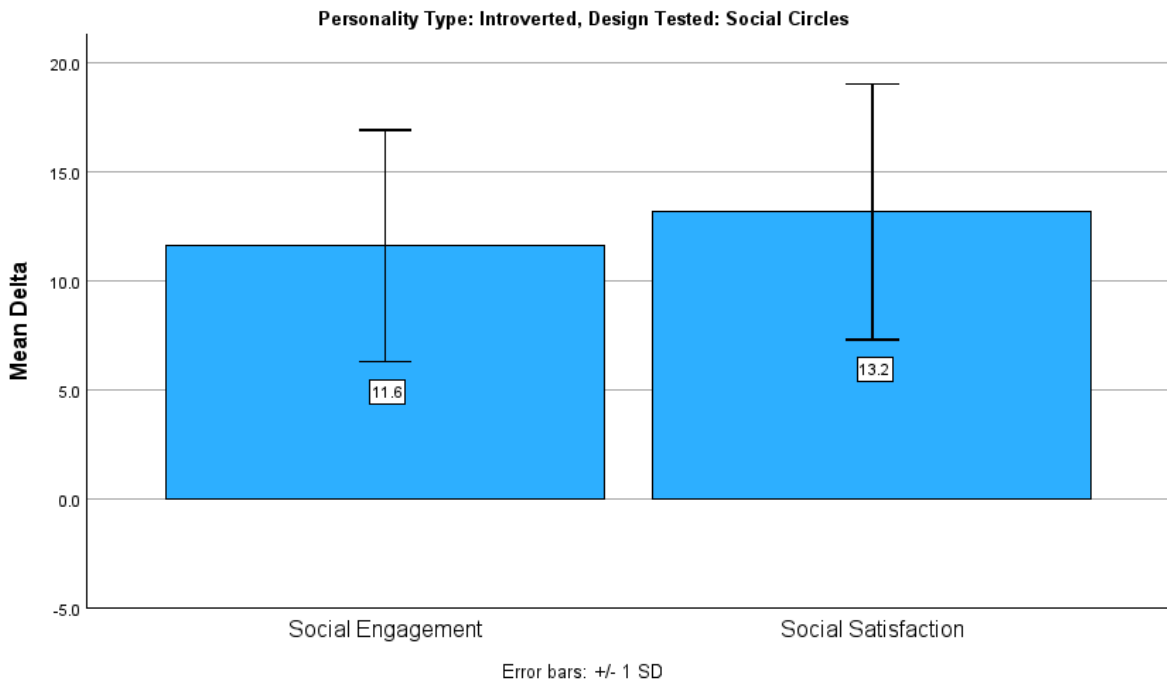
Fig 5.10 - Chart showing mean delta engagement and satisfaction for introverts testing Social Circles.

For extroverted participants, the **Social Circles** intervention had only a marginal impact on social metrics. The change in social engagement ((2.0 ± 2.8), t(9)=2.2, p=0.052) and social satisfaction ((1.4 ± 3.1), t(9)=1.4, p=0.196) scores were small, with only the change in social engagement approaching statistical significance **(Fig 5.9)**. In contrast, for introverted participants, Social Circles had a more noticeable impact, significantly increasing both social engagement ((11.6 ± 5.3), t(9)=6.9, p=<0.001) and social satisfaction ((13.2 ± 5.9), t(9)=7.1, p=<0.001) **(Fig 5.10)**. These results suggest that the Social Circles prototype had a more substantial positive effect on introverted individuals, improving the frequency and quality of their social interactions, with extroverted users only showing small tangible benefits.
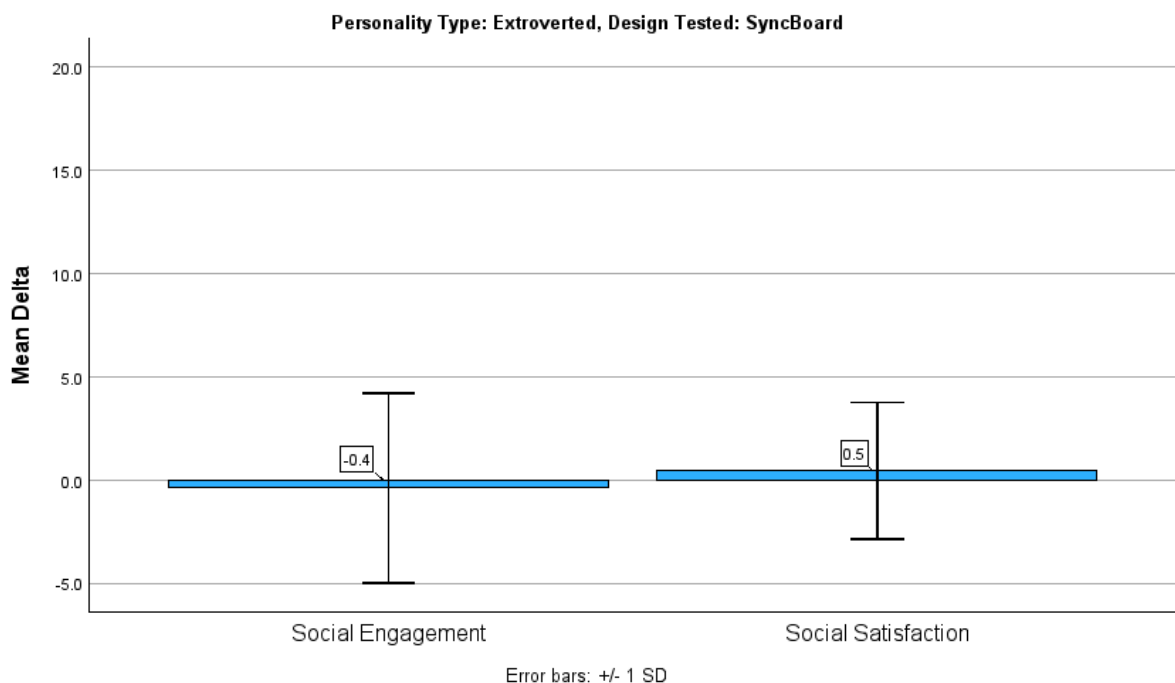
Fig 5.11 - Chart showing mean delta engagement and satisfaction for extroverts testing Syncboard.

Analysis of the **Syncboard** results show a similar trend. For extroverted participants, the impact on social metrics was negligible, with social engagement ((0.4 ± 4.6), t(9)=-0.3, p=0.790) and social satisfaction ((0.5 ± 3.4), t(9)=0.4, p=0.681) scores being statistically insignificant compared to baseline figures **(Fig 5.11)**. However, for introverted participants, Syncboard had a significant positive impact on social metrics, increasing both the frequency ((8.4 ± 4.5), t(9)=5.9, p=<0.001) and quality ((6.4 ± 4.9), t(9)=4.1, p=0.003) of their social activities **(Fig 5.12)**.
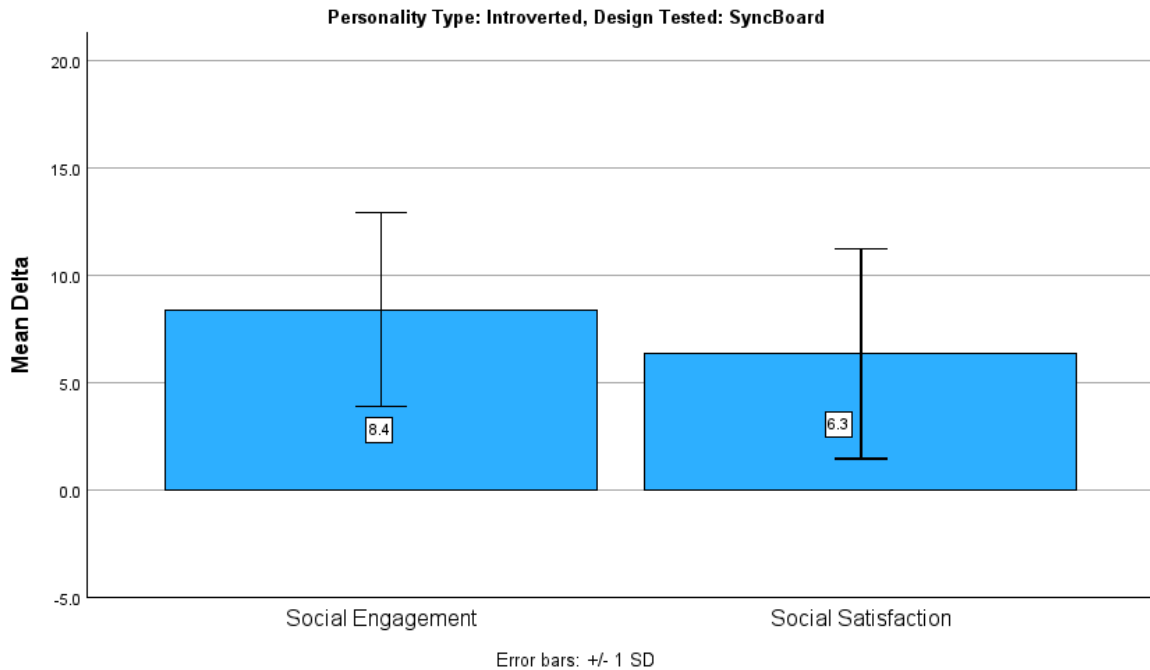
Fig 5.12 - Chart showing mean delta engagement and satisfaction for introverts testing Syncboard.

These findings highlight the potential differences socio-technical interventions can have on extroverted and introverted individuals, with introverts experiencing more significant benefits in social metrics as a result of interacting with these designs. This suggests there may be potential for tailoring interventions to address the specific needs of these personality types in combating social isolation.

While these results offer valuable insights, it is important to note a limitation in the analysis related to participants' baseline social metrics. Introverted participants initially had lower baseline scores, allowing for more room for improvement - a factor which may contribute to the greater impact shown by the interventions. However, due to the relatively small participant pool in this study, it is not possible to fully resolve this issue. Nonetheless, further analysis shows indications that suggest personality type, possibly in conjunction with baseline metrics, does play a significant role in determining the benefits of interventions.

The average improvement in engagement for the four extroverted participants with the lowest pre-testing scores - baseline scores similar to introverted participants - was only +2.0. In comparison, the four introverted participants with starting baseline scores similar to extroverts had an average improvement of +7.5. A similar pattern was observed for

satisfaction metrics, with the lowest-scoring extroverts showing improvements of -0.5, compared to a +4.5 change for the highest-scoring introverts. While these cursory comparisons would seem to indicate that personality type does influence the efficacy of isolation interventions, they are far from conclusive. Further research is recommended, with a larger sample size of participants, to gather more detailed insights into this relationship.

5.2.5 Quantitative Data Summary

An analysis of the questionnaire results from the prototype testing phase was conducted to assess the impact of HCI-based interventions on participants' social engagement and satisfaction. This analysis yielded valuable insights into the objective effectiveness of these interventions, and their impact on individuals' well-being, revealing a significant improvement in both social engagement and social satisfaction throughout the testing period. This supports the initial hypothesis that socio-technical interventions can help alleviate some of the adverse effects of social isolation, promoting a healthier social lifestyle.

The specific effectiveness of the two prototype interventions - **Social Circles** and **Syncboard -** were also explored. While both prototypes demonstrated statistically significant improvements in participants' social metrics, the Social Circles intervention had a more pronounced influence on both satisfaction and engagement. This suggests that synchronous interventions may be more beneficial, although it is important to consider potential advantages of the asynchronous solution that may not be evident from this dataset. Further exploration of participant qualitative feedback in **5.4** may shed more light on these trends.

One notable finding was the significant variation among participants, as indicated by relatively large standard deviations. Personality types of participants may have played a role in this variation. Extroverted individuals generally showed only minor improvements from the interventions, whereas introverted individuals experienced substantial enhancements in both social engagement and satisfaction. Further investigation through interviews and discussions will explore the subjective impressions and experiences of participants, that in turn could help interpret or explain these findings.

5.3 Prototype Testing Interviews & Discussion

Following the sequence of questionnaires during the prototype testing period, the study transitioned to a more qualitative approach, conducting one-to-one interviews and discussion sessions to gather insights, which are outlined in this section. The following discussion and analysis are based upon subjective responses to a set of interview questions, and associated discussions which provided user perceptions and impressions on the designs.

5.3.1 Overall Experience and Impact on Social Isolation

The participants' overall experiences with the prototype testing were mostly positive, with more than 75% of the feedback responses falling into positive and neutral categories. Most participants found the concepts intriguing, reporting increased interactions within their group because of their use. The **Social Circles** prototype was seen as primarily enhancing group communication and coordination. **Syncboard** was viewed as engaging and enjoyable, offering creative and collaborative opportunities. Most participants felt that the designs met their expectations, especially in addressing social isolation during non-standard social hours.

Extroverted participants had mixed experiences, often ranging from neutral to variable, with a few expressing mildly negative responses to the prototypes. Many extroverts preferred traditional communication methods over the Social Circles tool, and mostly had low expectations of the efficacy of the prototypes. A sizeable proportion of extroverts felt that the prototypes had little or no substantial impact on their feelings of social isolation.

I**ntroverted participants** primarily reported positive experiences, with only a few noting neutral or slightly negative impressions. Introverts felt a stronger connection with the Syncboard prototype, recognising its potential value as a collaborative art and therapy tool. Most introverted participants believed that the prototypes met or exceeded their expectations in addressing their sense of isolation.

Noteworthy Moments and Prototype Features: The Social Circles design led to increased social activities and events, particularly remote interactions like online games and group

movie-watching. Both extroverts and introverts experienced more frequent conversations, particularly outside of normal hours.

The Syncboard prototype evoked two contrasting experiences: one involving frequent use in collaborative art and drawing games, and the other indicating minimal interaction, often limited to brief notes. Collaborative art projects and user-created games were frequently mentioned. Introverts displayed more involvement with Syncboard, while extroverts had fewer interactions with the creative features. Users with creative interests and backgrounds were much more likely to connect with the Syncboard design.

In conclusion, participants' overall experience with prototype testing was positive, with variations between personality types and prototype preferences. Social Circles primarily improved the frequency of group interactions, while Syncboard served as a creative outlet. Extroverts and introverts showed distinct engagement patterns with each prototype. These insights indicate that individuals are broadly receptive to the utilisation of socio-technical interventions, but also that this receptivity can vary depending upon factors such as personality type and background interests.

5.3.2 Impact of Prototypes on Social Engagement and Relationships

The **Social Circles** prototype was described as enhancing group engagement through shared activities, something which seemed more beneficial for introverted users. It led to an increased incidence of both group and one-to-one conversations, especially outside normal social hours, and resulted in a more positive effect on relationships.

In contrast, the **Syncboard** design, while supporting a considerable number of frequent interactions, seemed to have minimal impact on relationship quality. However, many participants recognised Syncboard's value as a social creative platform, and as a tool for countering boredom and monotony, indicating a benefit beyond supporting social activity.

Overall, most responses reflected positive changes in social connections and relationships, including increased interaction frequency and participation in social events, mostly as a result of the Social Circles design. However, some users, particularly extroverts, noticed little

or no impact on their social lives as a result of the interventions. Syncboard had some effect on social connections but had a greater effect on treating boredom and monotony.

5.3.3 Synchronous vs. Asynchronous Designs

Frequency of Use: Social Circles was typically used infrequently, usually once per day, and usually only in the evenings, requiring prior knowledge of upcoming free time. Syncboard was used more frequently throughout the day and evening, due to its design allowing for frequent brief check-ins.

Usage and Impact: Social Circles focused on facilitating events and activities, which had intermittent but significant impacts on participants' social lives. Even on low-impact days, it showed an increase in out-of-hours conversation. Syncboard was seen as a fun, interactive tool that provided a consistent link between group members, offering a low but steady impact on social engagement. It had a smaller impact on social engagement in comparison to Social Circles, but instead served as an effective distraction from social isolation.

Catering to Needs and Preferences: Participants generally believed that the **synchronous** Social Circles design better aligned with their social needs and preferences. Extroverts in particular strongly leaned toward the synchronous solution, while introverts were more ambiguous, with some thinking both designs were equally capable. A small but significant number of introverts felt a strong affinity towards the **asynchronous** Syncboard design, with most of those with creative interests falling into this category.

In conclusion, the synchronous Social Circles design was more effective in reducing social isolation, due to its facilitation of larger-scale social activities. While Syncboard was more entertaining on its own merits, Social Circles had a greater impact on fostering social engagement, making it better aligned with participants' social needs and preferences, particularly among extroverts. Syncboard resonated strongly with participants who had creative interests and backgrounds, indicating that there is merit in varied intervention options in order to support a variety of individual preferences and needs.

5.3.4 Extroverted vs. Introverted Experiences and Adjustments

Social Circles: Extroverts found benefits in the ability to initiate spontaneous social encounters with minimal effort, appreciating the straightforward streamlined design. **Introverts** also valued the simplicity of the design, singling out the ability to initiate low pressure, spontaneous interactions. Introverts also appreciated that they were effectively anonymous when deciding whether they were available for social engagement, eliminating the fear of appearing unsociable or intrusive.

Introverted participants proposed the ability to target prompts to specific subsets of the social group, to support the occasional need for smaller, and lower pressure, social events.

Syncboard: Both personality types recognised Syncboard as a tool for entertainment and distraction, and celebrated its collaborative art potential.

Introverts, particularly those with a creative background, identified Syncboard as a useful tool for creative and therapeutic purposes. They did however express a desire to have an "appear offline" option, so that they could still engage in creative activities without being visibly available to other users. Introverts suggested that this could involve pausing their canvas synchronisation during this time, and to have their contribution added on a timed schedule. These adjustments would allow interactions while minimising direct social attention, catering to introverts experiencing anxiety or low mood.

In summary, extroverted and introverted participants had nuanced experiences with both prototype designs, with adjustments primarily focusing on supporting introverted users by enhancing control over social interactions and personal visibility.

5.3.5 Benefits, Challenges, and Improvements

Benefits and Positive Outcomes:

Social Circles: Participants experienced a surge in social events, including online games, movie-watching sessions, and in-person meetings. There was a significant increase in conversations, both 1-to-1 and group-based. These often occurred during unconventional

hours, sometimes including associated activities. Feelings of isolation and loneliness were reduced, with associated reports of reduced anxiety and improvements in mood.

Syncboard: Beneficial as both a therapeutic tool, and as an entertaining distraction, with collaborative art tools and user-created games both offering enjoyment and relief from boredom and monotony. Leaving handwritten notes on the board added a personal touch. While the direct impact on isolation and loneliness was relatively small, the design often left participants feeling more satisfied and less lonely.

> *"Completing a piece of artwork as a group was really satisfying. It felt like we were actually accomplishing something, even if the end result was a crazy mess!"*
> - Quote from participant #G011 during a post-testing interview.

Challenges and Drawbacks:

Social Circles: This design was identified as being significantly dependent upon regular user engagement, leading to minimal impact during low activity periods. Missed opportunities were also reported due to the need to open the app to view availability. Occasional glitches were reported, though these were rare and addressed during testing.

Syncboard: Challenges fell into three main categories:

1. **Functionality:** Perceived as a "blank slate" with little guidance, leading to a need for messaging tools, particularly for supporting user-defined games.

2. **Complexity:** The complex digital art tool interface was overwhelming for some users, making navigation difficult.

3. **Lack of interest**: Not all participants were interested in art or creative collaboration, resulting in reduced or intermittent usage.

> *"The only drawing program I've used before is Windows Paint, so the stuff on Magma was pretty overwhelming. Took me a while to get used to the basics, and I didn't use most of it."*
> - Quote from user #B033 from post-testing interview regarding Syncboard.

Suggestions for Improvements:

Social Circles:

- Expand participant capacity.

- Introduce more availability options like "gaming" and "movie".

- Add timers for activities like "coffee break".

- Incorporate timers to display the last availability change.

- Offer customisable availability options.

- Enable multiple networks/circles and sub-groups.

- Set 'away' periods for automatic availability blocking / silencing.

Syncboard:

- Implement built-in drawing modes, options, and frameworks.

- Simplify the user interface.

- Add a timeline function, allowing for real-time playback of the creation of art pieces.

- Allow upload of pictures and videos.

- Adapt the design to be more mobile-friendly.

In conclusion, participants identified a range of benefits stemming from both prototypes, with Social Circles promoting social events and conversations and Syncboard serving as an entertaining and therapeutic distraction. Challenges included dependence on user engagement, usability issues, and varying degrees of interest depending upon personal preferences. Valuable suggestions for improvements encompassed various features and enhancements that could potentially increase the designs' effectiveness, usability, and engagement across a broader audience.

5.3.6 Long-term Impact, Continued Usage, and Adoption Challenges

Long-term Impact on Reducing Social Isolation: Participants' impressions on the long-term impact of interventions were that socio-technical solutions show promise as a tool to combat social isolation effectively. Participants believed that consistent usage of **Social**

Circles could reduce feelings of loneliness over the long term, but also emphasised the need for a substantial user base to maintain positive outcomes.

Syncboard, with its collaborative art and therapeutic aspects, was also viewed as having the potential for long-term impact, with the notion that as a creative outlet it would have a strong use case as both a distraction from boredom and as a therapeutic tool.

In summary, participants recognised the long-term potential of both interventions, while highlighting the importance of addressing user base and tailoring to specific roles.

Continued Usage and Adoption of Similar Technologies: Participants showed a significant amount of interest in ongoing usage of these social technologies. Users believed that consistent use of **Social Circles** could reduce social isolation, with the caveat of needing a substantial user base. However, it was noted that similar 'availability' features exist as add-on features in other applications but are rarely used and mostly forgotten about.

Regarding **Syncboard**, participants, particularly those with creative interests, expressed enthusiasm for continuing to use it as a collaborative art and meditative therapy tool.

It is important to note varying participant responses, particularly for Syncboard, with some eager to continue while others are less interested. These differences underscore the need to design interventions that accommodate diverse preferences and interests, as observed in individualised responses during prototype testing and data analysis.

Challenges and Barriers to Widespread Adoption: A substantial userbase was suggested as being essential for the success of both interventions. Another major hurdle that was recognised by participants was the sustainment of that userbase over time, as the population of applications can wax and wane. Participants also highlighted accessibility and affordability as potential barriers that are likely to exist in concert, as an intervention that is expensive is also likely to be inaccessible for a broad audience. A suggestion was made to help to overcome these hurdles and broaden the user base, by offering mobile app versions of Social Circles and Syncboard alongside the proposed physical counterparts.

5.3.7 Example Case Studies

In order to respect the confidentiality of the study participants, the following case studies - Emma, Mia, and Alex - are composites that draw upon the character traits and responses shared by multiple participants. This allows for a representative account of user experiences, by distilling the broad pool of data into three major archetypes.

Case Study 1: Emma - The Creative Introvert

Background: Emma is an introverted individual with a strong creative background. She enjoys activities like drawing, writing, and participating in collaborative art projects.

Prototype Experiences:

Social Circles: Emma found Social Circles appealing due to its simplicity and ability to initiate low-pressure social interactions. She appreciated the anonymity that allowed her to engage without feeling intrusive. She primarily utilised the design during unconventional hours, engaging in one-to-one conversations and participating in online game sessions. These interactions provided a sense of connection without overwhelming her introverted nature.

Syncboard: Emma embraced Syncboard as a collaborative art tool. She enjoyed the creative outlet it offered and appreciated the personal touch of handwritten notes, which felt more intimate than text messages. She frequently joined in on art-based collaborative games, though she found the process of setting up the games would have benefited from built-in support. Emma was among those who expressed a strong interest in continued usage, as Syncboard aligned well with her creative pursuits. The therapeutic value of the design resonated with her, and she believed its impact could be long-term, especially if the design was further tailored to creative and artistic interests.

Challenges and Suggestions: Emma had no major challenges with either prototype design. She recognised the potential for improvements, such as a streamlined interface for Syncboard and additional creative-focused frameworks for Social Circles. Emma also

suggested the ability to appear offline while engaged in creative activities on Syncboard, catering to her introverted nature.

Key Takeaway: Emma's case study highlights the positive impact of the prototypes on creative introverts. Both designs provided avenues for creative expression and meaningful interactions, aligning well with her preferences and interests.

Case Study 2: Chris - The Extroverted Socialite

Background: Chris is an extroverted individual who thrives on social interactions. He is known for his vibrant personality, always seeking opportunities to connect with others.

Prototype Experiences:

Social Circles: For Chris, Social Circles served as a platform to initiate impromptu social encounters. He found the tool useful for organising in-person gatherings and quickly connecting with friends for online games. While Chris did not report significant improvements in meaningful interactions, he appreciated the streamlined interface and simplicity of the design. He engaged mostly outside of normal social hours, valuing the flexibility it offered.

Syncboard: Syncboard was less appealing to Chris due to its focus on creative collaboration. While he found the design to be a fun distraction, Chris preferred interactive social experiences and expressed minimal interest in using it for creative activities. He acknowledged its potential therapeutic value for others but believed it was not aligned with his extroverted personality.

Challenges and Suggestions: Chris faced no major challenges with the prototypes. His suggestions included incorporating more interactive elements into Syncboard and possibly introducing built-in communication tools to enhance its usability for users like him.

Key Takeaway: Chris's case study illustrates how extroverted individuals like his value platforms that facilitate spontaneous social interactions. While Social Circles met his needs, Syncboard's creative focus did not resonate as strongly with his extroverted nature.

Case Study 3: Alex - The Ambivalent User

Background: Alex has a mix of introverted and extroverted tendencies. Interests include creative pursuits, and they value simplicity and meaningful interaction.

Prototype Experiences:

Social Circles: Alex appreciated the low-pressure nature of Social Circles and its ability to initiate interactions without feeling intrusive. They engaged during unconventional hours, participating in group conversations and occasionally joining online game sessions. While they recognised its potential for impact, Alex remained ambivalent about long-term usage, indicating that the consistency of an engaged user base was crucial for its effectiveness.

Syncboard: Alex found Syncboard appealing as a creative outlet, occasionally participating in collaborative art projects. While they enjoyed its therapeutic aspects, Alex expressed a lack of consistent interest. They believed that tailor-made frameworks or examples could enhance the design's appeal for users like them.

Challenges and Suggestions: Alex suggested improvements for both designs, including more visible prompts for Social Circles and a streamlined interface for Syncboard. They felt that both prototypes had merit, but their continued usage would depend on factors such as user engagement and evolving features.

Key Takeaway: Alex's case study emphasises the nuanced experiences of individuals with mixed introverted and extroverted traits. They valued both prototypes' features but highlighted the importance of consistent engagement and tailored frameworks for sustained interest.

5.3.8 Concluding Thoughts

The exploration of the prototype designs and their impact on addressing social isolation has provided valuable insights into the preferences, experiences, and potential challenges faced by participants. Through a comprehensive analysis of responses to the interview questions and accompanying discussions, several key takeaways have emerged.

Key Takeaways:

1. Prototype Benefits and Positive Outcomes:

    a. Social Circles: Facilitated social events and conversations at unconventional times.

    b. Syncboard: Engaging for collaborative creativity and therapeutic purposes.

2. Challenges and Drawbacks:

    a. Social Circles: Dependency on userbase and regular engagement.

    b. Syncboard: Usability issues, lack of structured guidance, and varying interest levels.

3. Long-term Impact and Continued Usage:

    a. Interventions rewarding interaction and providing entertainment were valued.

    b. Existing interests may influence usage. Consistent usage is often critical.

4. Adoption Challenges:

    a. General need for a substantial user base.

    b. Accessibility and affordability are critical factors.

5.4 Prototype Testing Summary

This chapter has yielded valuable insights into both the objective and subjective impact of the tested interventions on social experiences. Furthermore, it has gathered valuable user feedback that can inform the development of future iterations of socio-technical tools based on user experiences and recommendations. Social Circles was the stronger design with regard to impact on the frequency and quality of meaningful social activity, as shown by the statistical analysis of **5.3.2** and supported by user responses in **5.4.2** and **5.4.3**.

Despite having a comparably less quantifiable impact on loneliness however, Syncboard was still viewed as a successful design due to its capabilities as a collaborative entertainment tool, providing a creative and therapeutic outlet along with novel game mode abilities that help to relieve isolation induced boredom and monotony.

The findings of this chapter highlight the benefits of tailoring design choices towards the interests and backgrounds of the prospective users, and the importance of ensuring accessibility and affordability of intervention solutions.

Chapter 6. Informed Design

Building upon the insights gained from prototype testing, and drawing from the knowledge acquired in the literature review, this chapter describes the refinement and evolution of the demonstration prototypes. This chapter highlights how the user testing has informed this development and showcases how that feedback has been integrated into their design.

6.1 Social Circles

The Social Circles design underwent a series of enhancements and adaptations in response to user feedback and recommendations collected during the prototype testing phase. This refinement process aimed to build upon the foundation of the demonstration model by addressing specific user needs and refining the overall user experience.

6.1.1 Intelligent Synchronisation

The original inspiration for this design concept was the "Synchroni-Link" workshop concept (see **4.1.2**), which leverages AI-driven automation to enhance social engagement. This AI system would analyse users' ongoing activities and assesses their availability for social interaction. When alignment occurs, it suggests potential connections, allowing users to accept or decline based on their preferences, promoting shared experiences. For example, if a user is engaged in a creative activity, the AI identifies this and seeks out others with similar interests.

This functionality was not included in the demonstration model of Social Circles, due to the complexity of an AI integration being cost and time prohibitive within the scope this research project.

However. this automated system could have significant benefits for the Social Circles design. This functionality would streamline the process of availability selection, which could mitigate the issue of irregular engagement and missed opportunities - issues recognised in **5.3.5**. The automated system could also facilitate more interactions outside of typical social timeframes, further improving and existing beneficial aspect of the design **(5.3.1).**

The AI system could be implemented either as an augmentation or replacement for the manual approach used in the Social Circles demonstration. This automation, combined with the design's distinct focus, diverse options, and tangible physical presence, sets it apart from traditional contemporary tools.

6.1.2 Additional Features

In response to user feedback and suggestions collected during the prototype testing phase **(5.3.5)**, the Social Circles design has been extended to encompass additional "availability" options. These options are designed to enhance the functionality and usability of the platform, providing users with a more tailored and versatile experience.

> "Something I miss now that I work from home, and that this app could be really useful for, is having a way to chat and network with people at work around the break room, in the same way Americans would chat around the water cooler."
>
> - Quote from #T036 during feedback discussions on Social Circles.

The following availability options have been included:

1. **Film Night:** This option allows users to indicate when they are available to watch movies or shows together within their social circles. It facilitates coordination for group viewing experiences, helping friends plan their entertainment activities. This activity would likely require either the ability to host an in-person gathering, or the addition of another service such as BigScreen, which allows for groups of people to meet in online virtual spaces and watch movies together as a social experience.

2. **Gaming Sessions:** The gaming option caters to the needs of users who wish to organise and participate in multiplayer gaming sessions with their social circles. It streamlines the process of scheduling gaming events, ensuring that everyone is on the same page regarding gaming activities.

3. **Work Breaks:** For users who want to stay connected with their social circles during work hours, the work break option offers a way to signal their availability during designated break times. It encourages brief yet meaningful interactions during work breaks. This facility was largely requested within the scope of using the Social Circles

design as a team-building tool, as a work-from-home replacement for the coffee break and water-cooler networking that would typically happen in an office environment.

4. **Eating Time:** This option lets users specify their meal times, allowing friends to know when they are available for virtual meals or simply to catch up during breakfast, lunch, or dinner. It fosters social connections over shared meal experiences.

Customised Modes

Due to the nature of this design, it may be possible to introduce a customisation feature, allowing users to create their own availability options within their groups. Users can define a custom icon and provide text to describe the purpose of their availability, enabling a highly personalised experience. However, it's important to note that while customisation enhances flexibility, it may introduce complexity and potential confusion. Thus, further testing and refinement will be essential to strike the right balance between flexibility and usability.

6.1.3 Availability Timers

Another highly requested enhancement centred around the incorporation of availability timers **(5.3.5)**. Users expressed the need to gauge when someone in their network last updated their availability status, providing insights into the timing of potential interactions. While particularly relevant for short-term availability states like tea or coffee breaks, this feature holds utility for various other modes as well.

To address this demand, the Social Circles design introduces an intuitive timing mechanism. It enables users to ascertain how long ago a contact modified their availability, helping them determine the appropriateness of initiating contact or joining in on a particular activity.

Fig 6.1 - Examples of tea and coffee break progress icons.

Fig 6.2 - Proposed timer layout for availability icons.

For options such as tea and coffee breaks, a straightforward visual indicator system is employed to convey the passage of time since the availability was set **(Fig 6.1)**. This system involves the gradual dissipation of "hot steam" icons over a user-defined timeframe . As these icons dissipate, they serve as a visual cue for others in the social network, offering a means to assess whether it's an opportune moment for a brief interaction. For more generic availability modes, a simple text indicator may be sufficient **(Fig 6.2)**.

For the 'Movie Night' availability option, a conventional timer element might prove insufficient, given the unique nature of the activity. To address this, an alternative approach is proposed, aiming to provide a user-friendly and informative experience. The icon for 'Movie Night' can display various states, each offering specific insights **(Fig 6.3)**:

1. **Take Your Seats:** This state indicates that someone is planning to watch a movie that evening at a specified time, with the proposed viewing time clearly displayed on the icon. This status remains until the scheduled start time of the movie, or until the user initiates the notification.

2. **Quiet Please:** When the movie is in progress, this state takes over. The icon could show the actual start time of the film, the elapsed time, or the time remaining in the movie. This allows other users to make informed decisions about whether they want to join in the movie-watching experience, even if they can't start from the beginning.

Fig 6.3 - Possible icon options for the Film Night availability mode.

In addition to these states, there's a possibility to add an option for when the movie is approaching its conclusion. However, this can likely be covered by the 'Quiet Please' state if it includes a 'remaining time' counter. Alternatively, a post-movie discussion period can be incorporated. This period enables users who have already seen the movie or couldn't allocate time to watch it to participate in the social conversation that follows the movie. During this time, participants can share their thoughts, discuss the film's pros and cons, and explore its themes, enhancing the overall movie-watching social experience.

By providing these versatile states, the 'Movie Night' availability option ensures that users can plan, join, and engage with movie-related activities in a manner that suits their preferences and schedules, promoting richer social interactions within their social circles.

For other availability options that could benefit from timer-based information cues, a straightforward timer element can be incorporated to provide users with essential information about when that status was last updated. This feature enhances the user experience by offering a clear indication of the recency of a particular availability status.

By incorporating availability timers, Social Circles not only enhances the user experience but also promotes more informed and considerate social interactions, aligning with the overarching goal of fostering meaningful connections within users' social networks.

6.1.4 Social Network Flexibility

"My social groups are a bit convoluted, especially if you add in the work team, and there are overlaps between them too. Would be interesting if this could be handled somehow."

- Quote from #T032 during post-testing discussions on the Social Circles prototype.

The ability to easily add and remove members of a social network to the design is an important function, requested by multiple participants of the user testing **(5.3.5).** An additional proposed feature related to the expansion of this functionality is the ability to dynamically control the relaying of availability to subsets of the social group, depending upon the mood and situation of the user - a functionality highly requested among introverted participants **(5.3.4)**.

The Digital Application: For the app-based demonstration model of Social Circles, adding additional friends to the social network is straightforward from a technical perspective, as the underlying database could handle hundreds of entries without issue. However, the primary challenge lies in optimising the user interface to accommodate a growing number of users while maintaining quick and easy visibility of updates.
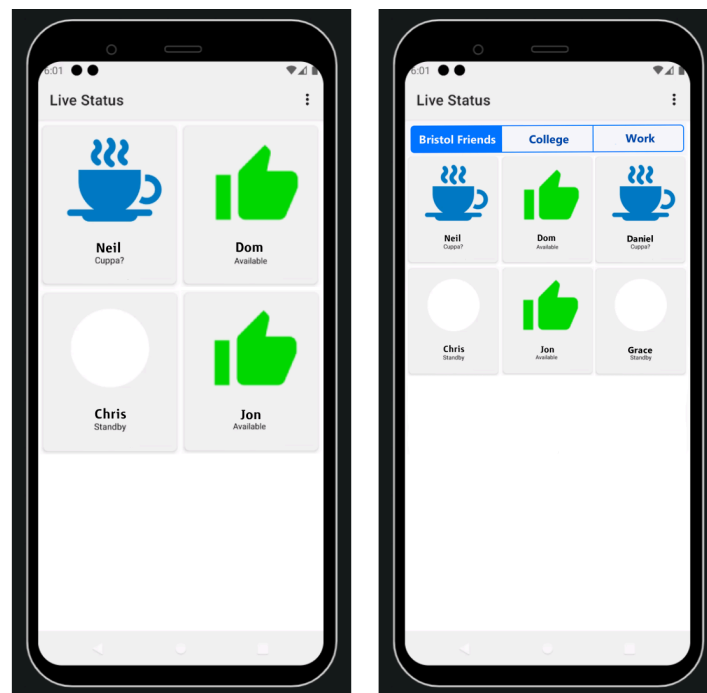
Fig 6.4 - Example panels comparing Social Circles demonstration app with preliminary revisions.

In the second panel of **Fig 6.4**, potential revisions to the application design are presented:

1. **Smaller User Cards:** Reducing the size of user cards and icons can increase the number of visible users to 12-15 (depending on phone screen size and resolution).

This resizing could be dynamic, adjusting the card size only when necessary due to an increase in the social network size.

2. **Social Network Tabs:** A row of tabs at the top of the screen allows users to manage and switch between multiple social networks and subsets.

It is important to note that these solutions pertain to the application-based variant of Social Circles. The original concept for all the interventions in this project was centred around physical devices offering tactile interaction and serving as a tangible prompt to combat social isolation. However, following recommendations from testing participants regarding affordability and accessibility, it may be beneficial to support the continued inclusion of an app-based version alongside the physical device **(5.3.6)**. This introduced unique interface challenges for the digital version to maintain feature parity that had to be addressed to maintain a seamless user experience.

6.1.5 The Physical Creation: Social Circles

The original design for the physical version of Social Circles involved a circular backplate holding a ring of small OLED screens displaying user availability icons. However, this design had limitations. If your social group was small there would be blank panels, and if your network was larger, expanding the circle was impractical. In the second panel of **Fig 6.5**, the prototype evolved so that each screen is an individual entity. This design freed itself from the constraints of the backplate, enabling users to add and remove these 'node' entities as needed - opening additional functionality and aesthetic options.

Fig 6.5 - Early and revised concept art for the Social Circles physical prototype.

Fig 6.6 - Social Circles revised concept art - Multiple Circles

Fig 6.6 shows how this new design might work with an expanded social circle, or even multiple social networks. The nodes can be arranged as shown in the rendered image, with the left-hand circle representing one social group and the right-hand circle representing a second independent social group. Overlapping users, like 'Chris' and 'Tim,' exist in both groupings. Moving the central node - representing the user's own availability - from one circle to the other could control which group sees your availability.

This setup introduces some complexities, especially when managing more than one social circle, but adds functionality that aids introverted users **(5.3.4)**. This preliminary render serves as an example of how it may work, but further experimentation and testing would be necessary to explore the feasibility and usability of these expanded functionalities.

6.1.6 Social Circles: Revision Summary

In response to user feedback and recommendations collected during the prototype testing phase and subsequent discussions in **Section 5.3**, the Social Circles design underwent a series of refinements and adaptations. These enhancements aimed to enhance the user experience and expand the functionality of the original demonstration model. Key refinements included the addition of a wider variety of 'availability' options, offering users a broader range of ways to express their social availability within the network and catering to different social needs and activities.

Another significant refinement involved the introduction of availability timers, allowing users to gauge when a friend's availability status had last changed. This feature was especially useful for short-term availability states like tea/coffee breaks, providing visual cues through icons that evolved over time. For 'Movie Night' and similar availability options, more intricate timing mechanisms were proposed, reflecting the unique nature of these activities.
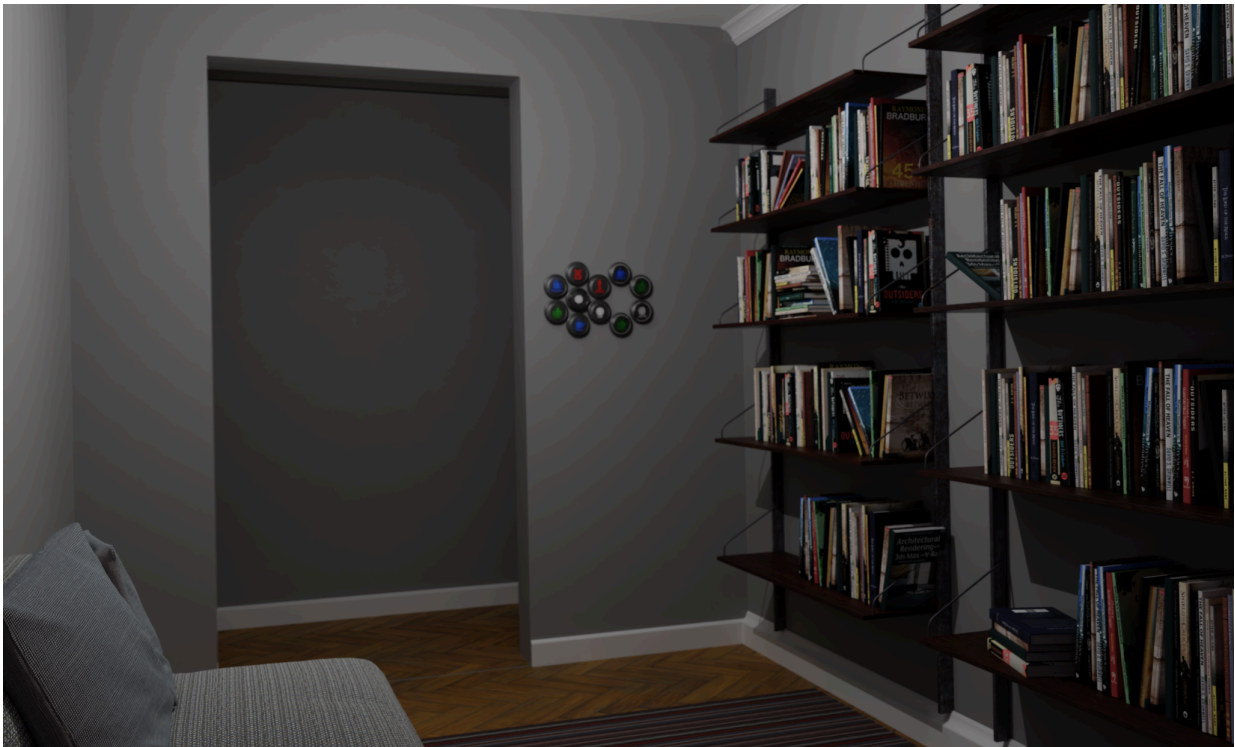
Fig 6.7 - A render showing an in-situ representation of the Social Circles concept.

The physical version of Social Circles evolved from a fixed backplate design to a more flexible individual node system **(Fig 6.7)**. This allowed users to adjust the number of nodes according to their network size and facilitated more advanced functionalities, such as managing multiple social circles. In the digital application variant of Social Circles, design improvements focused on accommodating larger social networks by shrinking user cards and introducing social network tabs. These changes aimed to ensure that users could easily access and manage their expanding networks.

In summary, the refinements to the Social Circles design were driven by user input and aimed to enrich the user experience by providing diverse availability options, improved timing mechanisms, and enhanced digital and physical interfaces. These adaptations reflect a commitment to addressing user needs and promoting social interaction.

6.2 Syncboard:Revised

The Syncboard design underwent a series of enhancements and adaptations in response to user feedback and recommendations gathered during the prototype testing phase. This refinement sought to elevate the original concept, aligning it more closely with users' expressed preferences and desires.

6.2.1 Victorious Vectors

One significant refinement in the Syncboard design involves transitioning from a raster-based tool, which is what Magma was based upon, to a vector graphics-based system, akin to Adobe Illustrator. This proposed shift is prompted by several considerations that favour vector graphics for the real-time update and timeline systems of Syncboard.

1. **Data Efficiency:** Vector graphics offer a notable advantage in terms of data efficiency. Unlike raster graphics, which store each individual pixel's colour information, vector graphics represent images using mathematical equations. This means that vector-based drawings are inherently smaller in size, reducing the data transmission and storage requirements when users collaborate in real-time. In the context of Syncboard, where multiple users interact with the canvas concurrently, this efficiency is crucial for maintaining a smooth and responsive experience.

2. **Scalability:** Vector graphics excel in scalability. They can be resized without any loss of image quality because they rely on mathematical formulas to render shapes and lines. This scalability aligns perfectly with Syncboard's need to accommodate various screen sizes and resolutions, ensuring that the collaborative canvas looks consistent and maintains its quality, regardless of the device being used. It also allows for unlimited panning and zooming into the canvas, as even when expanded to fill the screen an image will remain crisp and sharp **(Fig 6.8)**.
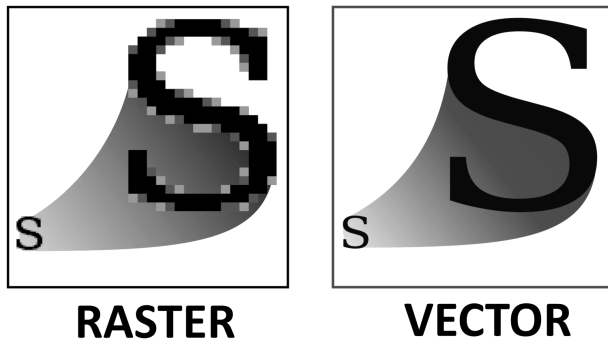
Fig 6.8 - A diagram demonstrating raster vs vector based graphics.

RASTER   **VECTOR**

3. **Editing Flexibility:** Vector graphics provide unparalleled flexibility when it comes to editing. Shapes and lines can be easily modified, resized, and manipulated without degradation in quality. In Syncboard, this translates to effortless editing of collaborative artwork, empowering users to refine their contributions with precision.

4. **Timeline Integration:** The transition to a vector-based system simplifies the integration of a timeline feature, a fundamental aspect of Syncboard's design. In a vector environment, changes to drawings and animations can be tracked more efficiently over time. This facilitates the creation of animations, visual storytelling, and interactive elements within Syncboard, enhancing its creative and collaborative potential.

5. **Resource Efficiency:** Vector graphics impose fewer demands on hardware resources. They require less processing power and memory than their raster counterparts, making Syncboard more accessible to a wider range of devices, including smartphones and tablets. This resource efficiency contributes to Syncboard's goal of inclusivity and accessibility.

By embracing vector graphics, Syncboard has optimised its core framework for efficient real-time collaboration, flexibility in editing, scalability, and resource management. This transition underscores Syncboard's commitment to delivering a seamless and user-friendly experience while empowering users to engage in creative collaboration without the limitations associated with raster-based tools.

6.2.2 User Modes

The initial prototype presentation of Syncboard was intentionally a 'blank-slate', serving as a digital collaborative whiteboard equipped with a diverse range of graphical tools. This approach encouraged user interaction and creative exploration without imposing specific guidelines. The prototype was offered as a digital playground, allowing users to organically discover modes of interaction and operation.

Fig 6.9 - Two 'exquisite corpse' compositions, formed from collaborations of multiple users.

Consequently, both anticipated and unforeseen user-generated modes emerged during testing, indicating the diverse ways users adapted the prototype to their needs. These modes emerged naturally within test groups, where participants with similar backgrounds or cognitive processes gravitated toward similar concepts. In response to feedback and recommendations from participants, the revised Syncboard design includes the integration of additional modes to augment the user experience:

Game Mode 1 - MeldScape: Inspired by the 'Exquisite Corpse' art method, where collaborative art pieces are added to a composition until a whole image is formed. User feedback provided two individual 'subtypes' for this mode of operation **(Fig 6.9)**:

1. **Layer by Layer:** Participants take turns adding to the composition. Subsequent contributions are layered over existing work, enabling non-destructive alterations and facilitating collaborative improvement. This mode allows for the gradual development of an evolving landscape or scene, starting with a background and progressing to intricate foreground details.

2. **Region by Region:** This structured approach divides the canvas into regions, assigning each participant to a specific zone for drawing. Contributors can opt for sequential creation, ensuring a cohesive composition, or simultaneous drawing for a more eclectic result. Zones can be guided by prompts, encouraging thematic cohesion or variety.

   Zone layouts: The canvas can be generated with a variety of region options, with the option to choose the layout option manually, or allowing the system to select one randomly when the canvas is generated **(Fig 6.10)**.
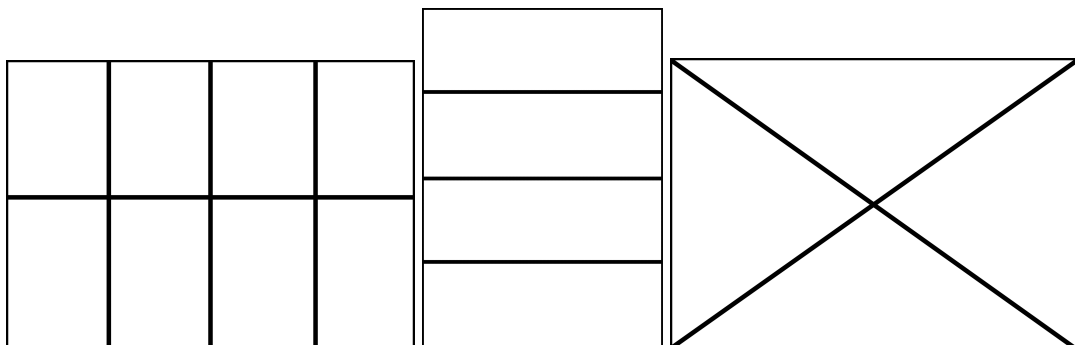
Fig 6.10 - Diagrams showing a selection of possible canvas region layouts.

Game Mode 2 - Doodlephone: A Collaborative Drawing and Guessing Game. Responding to a widely requested game mode, the DoodlePhone game mode within Syncboard was inspired by the well-known "Doodle or Die" game, which combines elements of "telephone" and "Pictionary." The game starts with a player receiving a randomly generated prompt,

which they must then illustrate. The next player views this drawing and attempts to guess the original prompt. This process alternates between drawing and guessing prompts, resulting in a sequence of evolving drawings and interpretations **(Fig 6.11)**.

Fig 6.11 - An example 'Doodle or Die' game progress, started by the prompt "A Bear in the River".

However, the initial demonstration of the Syncboard prototype posed challenges for this game mode. DoodlePhone requires that previous entries in the sequence remain hidden, with only the latest step visible to the current player. Additionally, the game mandates that prompts and images be automatically sent to the next player in the chain, with no other users having access to them. The demonstration prototype, being a live-view canvas, did not support these features. Moreover, the final outcome necessitates that images be saved in sequence for correct display.

To facilitate the DoodlePhone mode, the following adaptations were proposed:

1. **Separate Instance:** Developing a dedicated interface, such as a pop-up overlay window, for displaying the game to individual players. This would prevent any interference with the primary real-time canvas.

2. **Randomised Prompts:** Enabling Syncboard to generate randomised prompts, initiating games and ensuring variety and creativity.

3. **Sequential Turn Storage:** Implementing a system that stores completed turns and automatically forwards them to the next player in the sequence. Users would receive notifications about available turns, maintaining the flow of the game.

Game Mode 3 - CaptionArt: Another widely requested mode inspired by popular games like "Drawful" that involve drawing and guessing based on quirky prompts, has been considered for integration with Syncboard **(Fig 6.12)**.

Fig 6.12 - Examples of turns in the Drawful game, courtesy of JackboxGames.

To facilitate this game mode within Syncboard, the following adaptations have been recommended:

1. **Distinct Instance:** A separate interface will be developed specifically for the game mode, ensuring that it operates independently of the main canvas and does not disrupt the primary user experience.

2. **Randomised Prompts:** Syncboard will be equipped with the capability to generate random prompts, initiating games with unique and creative challenges.

3. **Captioning Process:** The application will gather completed drawings, distribute them to all players, and provide prompts so that players can then generate captions and make their guesses.

User Modes Summary

These user-generated game modes, inspired by participants' feedback and preferences during prototype testing, showcase the versatility and adaptability of the Syncboard design. They reflect the potential of Syncboard to cater to a diverse range of user interactions and preferences. By incorporating these engaging game modes, Syncboard aims to enhance user engagement, encourage social interactions among friends, and alleviate feelings of isolation.

A key consideration for each of these propositions is the importance of integrating functionality seamlessly, ensuring that the user interface remains intuitive and uncluttered, providing a user-friendly experience. This approach aims to make these game modes accessible and enjoyable for all users.

6.2.3 User Interface

"There's a lot going on, and the icons are too small on my tablet. Seems more catered towards a desktop monitor than a tablet."
- Quote from participant #B006 during post-testing interview.

The complexity of the user interface emerged as a recurring concern during discussions about the Syncboard prototype. It is important to clarify that the majority of this interface was not originally intended as part of the proposed design. Instead, it was a component of the Magma platform utilised for the demonstration. This was a compromise necessitated by the need to create a functional prototype for testing within the project's resource constraints.

The interface complexity and its potential bias towards desktop monitors over tablet devices were unintended outcomes of this compromise. To address this issue, the proposed redesigned Syncboard design prioritises a streamlined and intuitive user interface, one that is optimised for various devices, including tablets. This approach ensures that users have a seamless and user-friendly experience, regardless of their choice of device.

The new user interface design focuses on clarity, ease of navigation, and accessibility. It aims to provide users with an uncluttered and efficient environment, empowering them to engage with Syncboard effortlessly and effectively. The user interface's responsive nature

ensures that it adapts to different screen sizes and devices, fostering inclusivity and enhancing the overall usability of Syncboard.
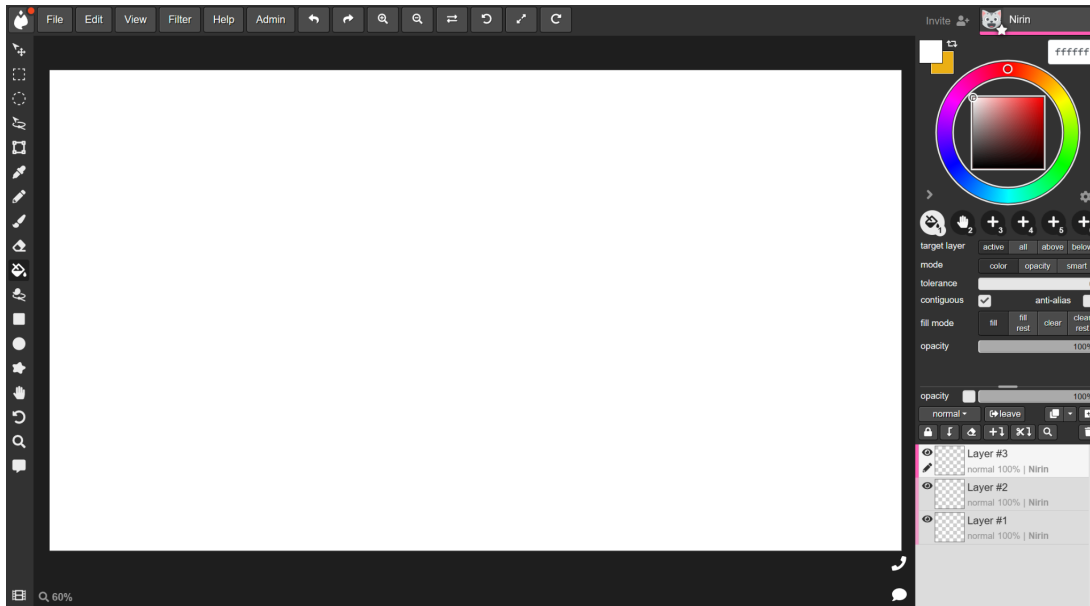
Fig 6.13 - The Syncboard demonstration user interface, courtesy of Magma.com.

The user interface of the Syncboard demonstration faced various challenges and concerns highlighted by the prototype testers. Notably, the permanent left-edge toolbar and top-edge menu, while occupying a relatively small portion of the screen, were identified as taking up valuable screen real estate **(Fig 6.13)**. However, the primary source of concern was the right-edge sidebar. This sidebar, when open, consumed a significant portion of the screen and could only be partially minimised. Furthermore, it was criticised for being cluttered and overly complex, featuring an abundance of unnecessary settings and options.

This complexity and clutter resulted in confusion and feelings of overwhelment, especially among participants with limited prior experience in digital art software. Even participants with prior experience found the user interface overly intricate for the prototype's requirements.

To address these issues, the revised proposed prototype, unconstrained by the need to use pre-existing software, will undergo substantial refinements in user interface design and development. The initial phase of this redesign will involve incorporating design elements commonly found in tablet-based digital art tools. This approach aims to enhance user-friendliness, streamline the interface, and ensure that users, regardless of their

familiarity with digital art software, can interact with the Syncboard intuitively and without feeling overwhelmed. These improvements are essential to provide a more accessible and user-centric experience.
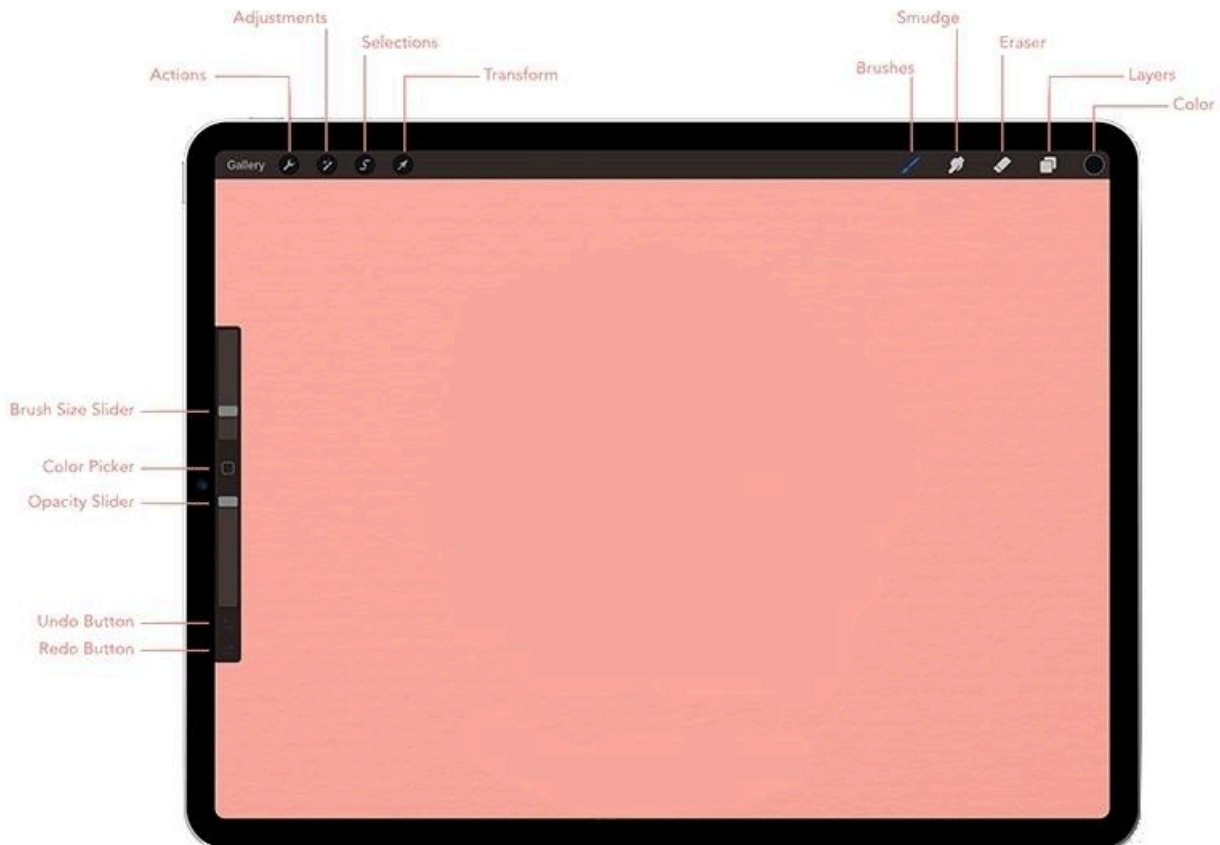
Fig 6.14 - The user interface design for Procreate on iPadOS, courtesy of Savage Interactive.

Existing tablet-based digital art tools, like Procreate for iOS and iPadOS, as well as Sketchbook for Android, have undergone numerous iterations of UI refinements throughout their development. These refinements have been informed by user feedback, resulting in interaction styles that have since become industry standards, widely emulated by similar art applications. Learning from the existing standards, based upon years of user-centric iteration, is an important step in the process of creating functional and accessible designs. As demonstrated in **Figure 6.14**, the standard UI of Procreate is notably cleaner, featuring only a top-edge menu and a partial left-edge toolbar.
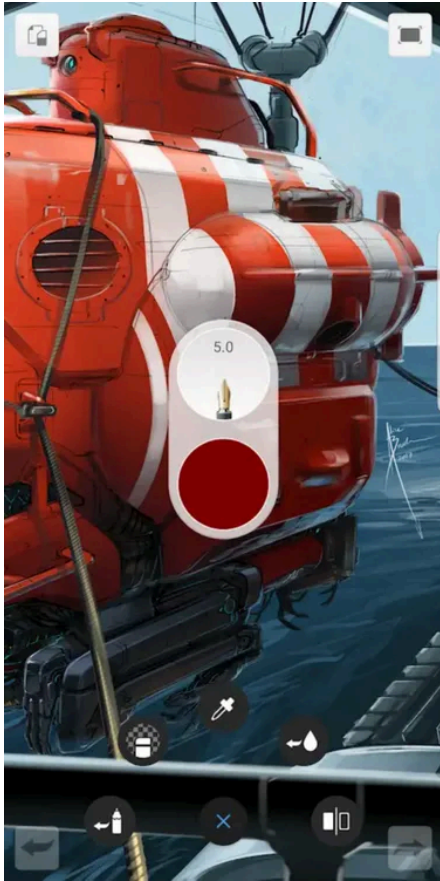
Notably, Sketchbook diverges from traditional toolbar menus for adjusting brush size and opacity, instead employing a gesture-based system. A long-press on the screen activates the brush pop-up, as seen at the centre of **Fig 6.15**. While maintaining contact with the screen, dragging up and down adjusts the brush size, while moving left and right modifies the opacity.

Fig 6.15 - Autodesk Sketchbook, shown on an Android phone.

These user-friendly and unobtrusive UI designs enhance the user experience by offering a clean and clutter-free canvas for creativity. This approach prioritises ease of use and intuitive interactions, ensuring that users can focus on their artistic endeavours rather than navigating complex menus.

Drawing inspiration from the design principles of successful digital art tools like Procreate and Sketchbook, the redesigned Syncboard prototype aims to achieve a more streamlined and user-friendly interface. By leveraging these established user-centred design elements that have undergone years of refinement, Syncboard intends to offer an intuitive and efficient user experience. The primary objective is to simplify the user interface, minimising clutter and complexity, while providing users with a familiar and accessible platform for creative collaboration. While both Procreate and Sketchbook offer a wide array of digital art tools similar to the tools available in Magma, the Syncboard design can take simplification and streamlining to an even higher level. This streamlined approach is possible because

Syncboard does not require the full range and depth of professional digital art tools for many of its intended modes and services. Based on the feedback obtained during prototype testing discussions and the analysis of existing UI setups for contemporary tablet digital art tools, the following design parameters have been identified:

1. **Non-Fixed UI elements:** The user interface should employ contextual elements that appear when needed and disappear once an option has been selected. Although this may slightly slow down the selection of options (requiring two touch-presses instead of one), it significantly increases the usable canvas space, providing a more immersive and less cluttered experience.

2. **Simplified Options:** The interface should prioritise simplicity by offering only essential digital art tools. Complex sub-tools and options, typically designed for professional users, should be omitted. This simplification not only enhances usability but also reduces the need for intricate UI elements to select and control advanced features.

3. **Streamlined Navigation:** Implement intuitive navigation controls that facilitate easy access to different functions and modes. A logical and user-friendly menu structure should guide users through various interactions without overwhelming them with unnecessary complexity.

4. **User-Centric Customisation:** Allow users to customise their UI to some extent, enabling them to arrange and prioritise tools according to their preferences. This flexibility ensures that Syncboard caters to a broader range of users with varying needs and preferences.

These design parameters serve as the foundation for refining the Syncboard user interface, with a focus on improving usability and enhancing the overall user experience.

Fig 6.16 illustrates a proposed default layout for the Syncboard concept, showcasing a design approach that eliminates fixed-position toolbars and maximising usable canvas space. Instead of complex UI elements, simple and recognisable icons are used alongside

text labels for clarity and accessibility. This minimalist design prioritises a distraction-free and intuitive user experience.
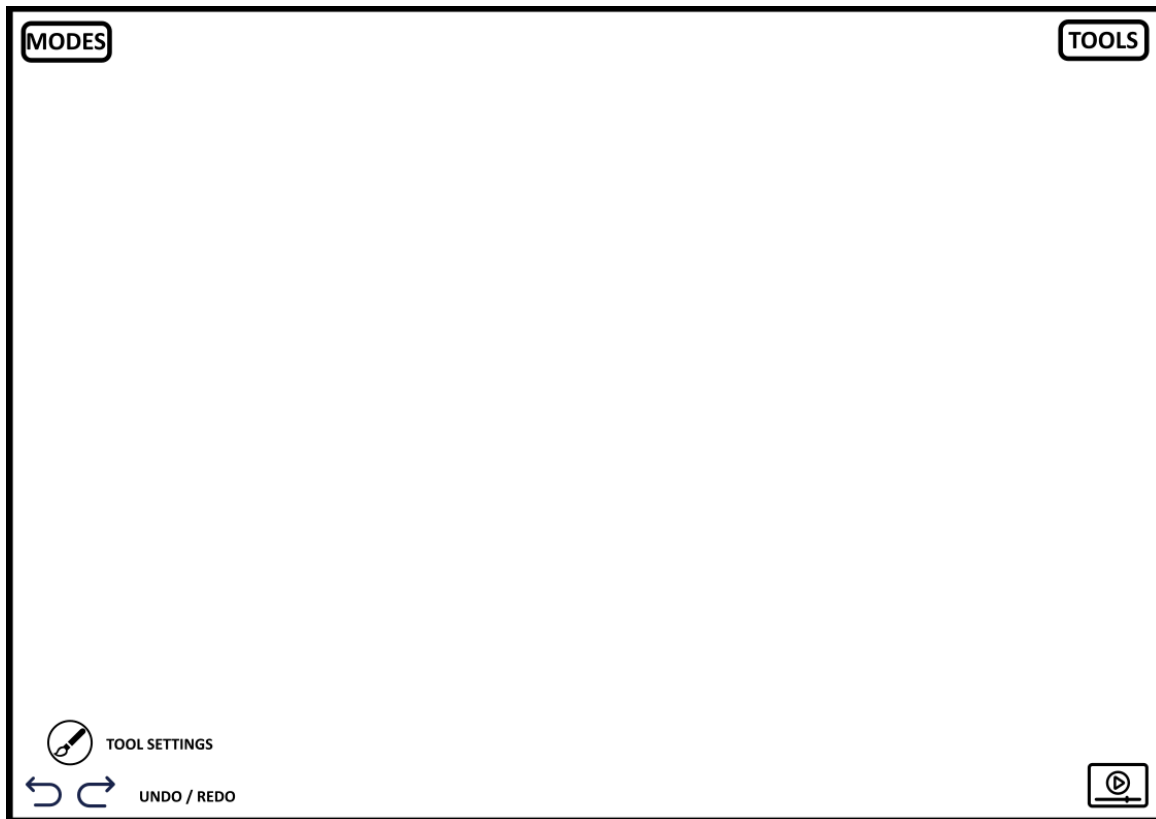
Fig 6.16 - Default Layout: Proposed layout concept art for Syncboard.

Fig 6.17 - Game Options Layout: Proposed layout concept art for Syncboard.

In the subsequent demonstration diagrams, text labels have been included with the icons to aid in explanation and guidance. However, it is anticipated that these labels will be optional and can be toggled off once users become familiar with the iconography **(Fig 6.17)**. This

customisation feature allows users to further declutter the interface and tailor it to their preferences, promoting a user-centric approach to UI design.
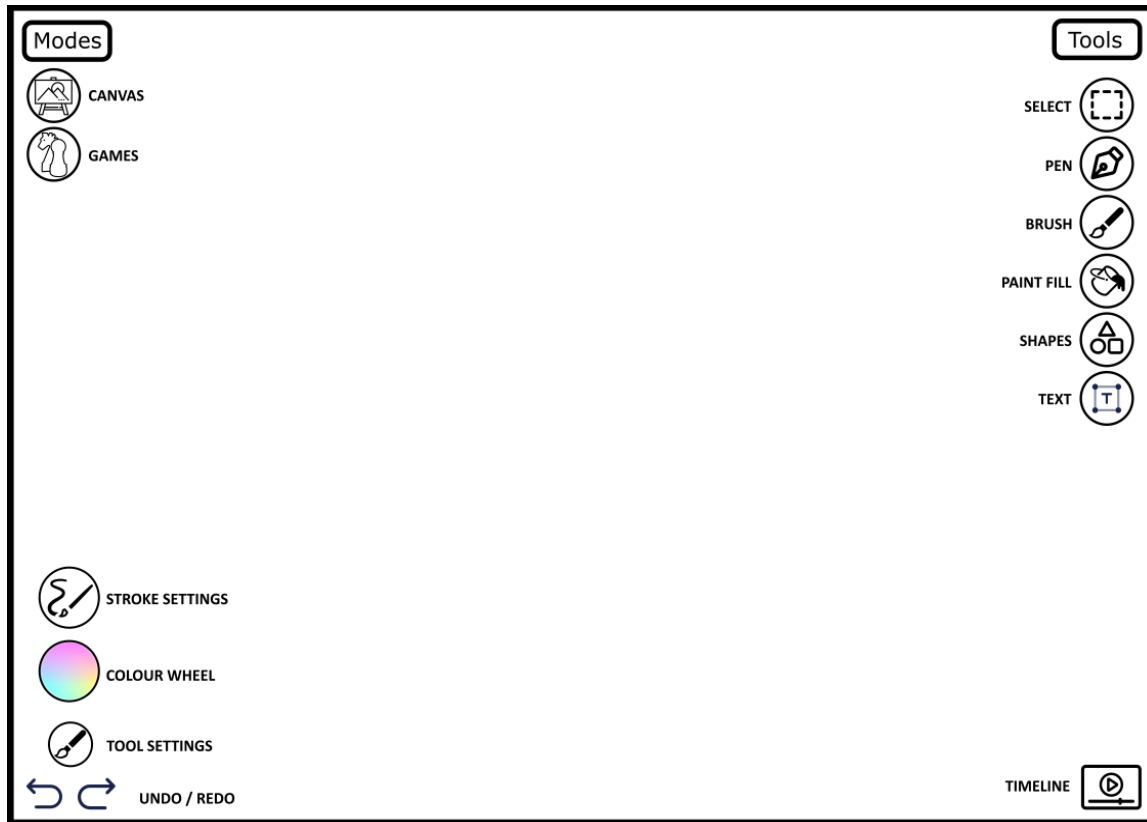
Fig 6.18 - All Options Layout: Proposed layout concept art for Syncboard.

The redesigned Syncboard prototype introduces a simplified and user-friendly set of tools accessible through the 'Tools' option **(Fig 6.18)**. These tools have been thoughtfully selected to streamline the creative process while ensuring a clutter-free and efficient user interface. The included tools are as follows:

1. **Select**: This tool allows users to easily select components on the canvas for tasks like moving, editing, or deleting. It simplifies the process of working with different elements in your artwork and facilitates copy-paste operations.

2. **Pen**: The Pen tool is a vector-based drawing tool that enables point-and-click art creation. Users can tap on the canvas to create points, and the tool automatically connects them using editable Bezier curves. It's essential for both creating new elements and editing existing strokes and shapes.

3. **Brush**: The Brush tool offers a more freeform approach to creating strokes and shapes. Users can draw strokes on the canvas with a stylus or fingertip, mimicking the feel of using a real pencil on paper. The tool translates these motions into vector-based strokes, fostering artistic freedom.

4. **Paint Fill**: With a chosen colour, users can easily fill enclosed shapes on the canvas by tapping within them. This tool simplifies the process of adding colour to your artwork.

5. **Shapes**: Syncboard includes a small selection of basic shape templates, such as squares, triangles, and circles. Users can drag to create shapes of various sizes, providing a quick and effortless way to incorporate basic geometry into their designs.

6. **Text**: For in-concept communication and annotation, Syncboard offers a simple text tool. While it provides limited font and kerning options, it fulfils the request for basic text entry on the canvas. This feature is designed to be user-friendly and straightforward, though it would also require the inclusion of some form of on-screen keyboard.

Each of these tools has been chosen to cater to a wide range of creative needs while maintaining the commitment to a minimalist and distraction-free user interface. This selection ensures that users can efficiently express their ideas and collaborate with others seamlessly. The redesigned Syncboard prototype incorporates intuitive tools for adjusting stroke settings and paint colours. These settings are designed to be easily accessible without cluttering the user interface **(Fig 6.19)**.

Colour Wheel: When you tap the tool icon in the 'Tool Settings' controller while drawing, it reveals the 'Colour Wheel.' This tool offers an RGB gradient colour wheel, allowing you to select the perfect paint colour for your current tool. You can simply drag the selector around the wheel to change the paint colour quickly and precisely.

Stroke Settings: The 'Stroke Settings' gadget, while providing advanced options, is designed for ease of use. When visible, you can adjust stroke settings by dragging your finger or stylus on the screen. Dragging up and down will change the stroke width of the

currently selected tool, while dragging left and right will adjust opacity. These straightforward controls offer a wide range of customisation possibilities, enabling you to fine-tune your strokes and achieve the desired artistic effects.
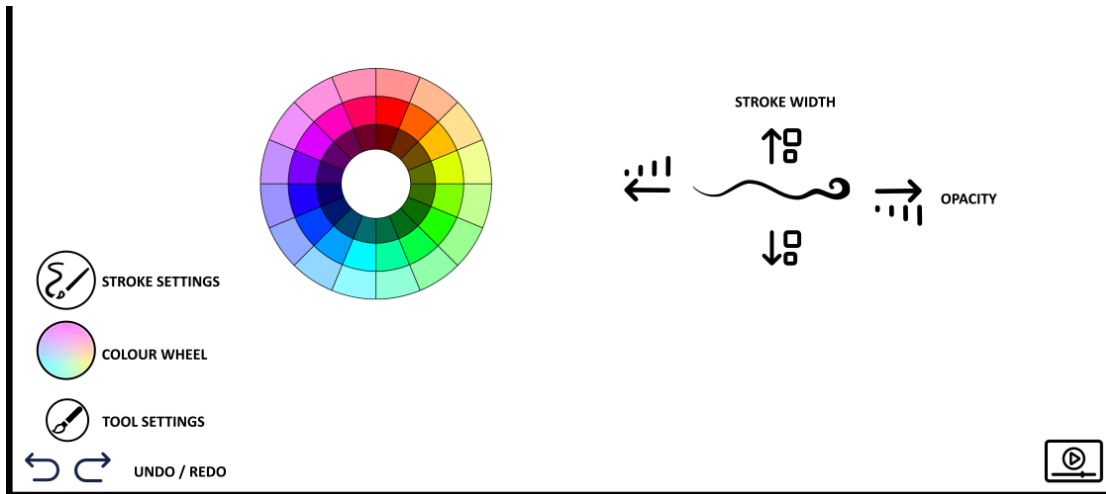
Fig 6.19 - Tool Settings Layout: Proposed layout concept art for Syncboard.

These settings are integrated seamlessly into the Syncboard interface, ensuring that users can make precise adjustments while focusing on their creative process. The goal is to provide a user-friendly and efficient experience, allowing for versatile artwork creation without unnecessary complexity.

The 'Timeline' also has an icon as part of the UI, but this function will be discussed in further detail in a subsequent section of this chapter.

The illustrative images presented here serve as conceptual designs, and iterations of them have been shared with prototype testing groups for preliminary feedback as part of this refinement and recommendation process. However, they have not undergone extensive testing in controlled environments to evaluate usability, legibility, or the necessity of specific options. In-depth testing would be essential to gather crucial data on user experience and interface effectiveness.

While the core functionality of Syncboard does not demand the full spectrum of graphics tools found in professional art applications, there may be merit in including "creator" level options within the design. This addition could attract users with creative or artistic interests

and make Syncboard even more versatile. However, since this feature might be user-dependent and could involve additional hardware requirements, it would be advisable to make such advanced features a customisation option, rather than a fixed default. This approach ensures that Syncboard remains accessible and user-friendly for a broad audience while catering to the needs of more specialised users.

6.2.4 Timeline

A pivotal element of Syncboard is its ability to facilitate asynchronous usage, a feature that significantly enhances its usability in real-world scenarios. This function, while complex due to the canvas's real-time nature, plays a crucial role in extending the concept's utility.

The timeline mode in Syncboard would allow users to pause the canvas, or log the point in the timeline when they last interacted with the device. When a user returns to the device, several symbols can be displayed on the timeline to convey various events, enhancing the collaborative experience. Examples of these symbols, as illustrated in **Fig 6.20**, may include:

1. **Coloured/Avatar Icons:** These icons can indicate when other users last interacted with Syncboard and created new artwork or updates for collaborative activities. These icons could be instrumental in promoting awareness of ongoing collaborative efforts, fostering engagement, and allowing users to keep track of their peers' contributions.

2. **Timeline Icon:** The timeline icon represents the current position of the playhead for the individual user. By pressing this icon, users can initiate a play-through of activities that occurred since their last interaction with the device. Alternatively, users can manually drag the play marker through the timeline, allowing them to revisit previous updates and interactions. This feature offers users a novel and dynamic way to explore collaborative artworks and content.
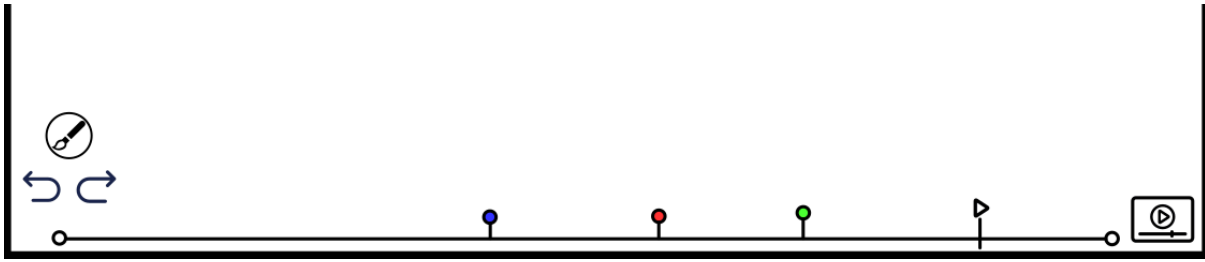
Fig 6.20 - Timeline Layout: Proposed layout concept art for Syncboard.

The timeline functionality in Syncboard serves multiple essential purposes. It accommodates users' varying schedules, making collaborative efforts more inclusive and providing visibility into the collaborative process. This feature also allows users to store and revisit the entire history of collaborative social communication, creating a unique 'living' collaborative art piece. Additionally, it transforms Syncboard into a dynamic platform for creative collaboration and storytelling. Users can navigate through the timeline to explore the evolution of artwork, games, and other activities, enhancing their overall experience. In summary, the timeline is a crucial component of Syncboard's design, bridging the gap between real-time and asynchronous collaboration and offering users a dynamic platform for creative expression and social interaction.

6.2.5 The Physical Creation: Syncboard

From the inception of this design, the concept for Syncboard was that of a wall-hanging whiteboard, of the kind found in many kitchens, bedrooms and studies. The design features an LED touch-screen panel with a screen size of approximately 30 - 45cm (measured diagonally) - a size chosen as a balance between wall-mounted visibility and usability when used handheld or placed on a table for extended creativity sessions.

This physical design allows for multi-purpose functionality to be built in to the device, by including visual options that cater to the use-cases that typical whiteboards or other wall-mounted items would be used for, such as:

- **Aesthetics:** The default collaborative canvas view could be used as a living art piece, taking the place of photos or paintings. There would also be the option of using Syncboard as a digital picture frame, or potentially as a 'smart mirror' device.

- **Organisation:** A screen option could be a non-synchronised 'private' canvas, which can be used to leave notes to yourself or other family members.

These options allow for a more hybridised utilisations of the design, giving it more usefulness for a potential user and making it more worthwhile for inclusion in a home, which in turn would improve accessibility and the chances for regular engagement.

Fig 6.21 - Revised version of Syncboard, including timeline controls.

With the addition of a dedicated physical design for Syncboard, the concept could include additional interaction options. In **Fig 6.21** the example shows how a dedicated design allows for the inclusion of tactile control options, including a tracking slider on the device that allows users to scroll backward and forward on the timeline through the entire 'play history' of the canvas. The intention behind such tactile user-interactive elements is to improve usability and functionality of the device, while perhaps making it more engaging and entertaining to use. It would be recommended to put these physical controls through thorough iterative testing, to refine the design and explore their impact on functionality.

6.2.6 Syncboard: Enhancing Collaborative Creativity and Interaction

Syncboard represents a multifaceted approach to foster collaborative creativity and alleviate social isolation. During the prototype testing and discussions, several key elements were identified as requiring refinement to improve its effectiveness.

Shifting from a raster-based tool, like Magma, to a vector graphics system akin to Adobe Illustrator would bring several advantages. It enhances data efficiency, ensuring real-time

updates and smooth performance. Additionally, it would offer scalability, allowing users to zoom in without loss of quality and ensuring that artwork retains its clarity and crispness, promoting a richer collaborative experience.

Introducing built-in support for interactive game modes, inspired by participant feedback and preferences, can promote social engagement and creativity. DoodlePhone, inspired by "Doodle or Die," encourages players to create and guess prompts, resulting in evolving drawings and interpretations. CaptionArt, influenced by "Drawful," tasks players with interpreting quirky prompts and comically inaccurate drawings. These game modes provide users with entertaining and interactive ways to connect, collaborate, and combat social isolation.

Fig 6.22 - An in-situ representation of Syncboard in a kitchen environment.

User feedback and insights from existing tablet-based digital art tools like Procreate and Sketchbook have driven the recommendations behind the preliminary design of Syncboard's user interface. The UI design emphasises non-fixed UI elements, contextual toolbars, and simplified options. This approach reduces clutter, enhances usability, and maximises canvas real estate, ensuring that the interface remains intuitive and user-friendly.

At the heart of all of this is the inclusion of Syncboard's timeline functionality, enabling asynchronous interactions and enhancing the collaborative experience. Users can pause the canvas or mark their last interaction point. When revisiting the device, the timeline reveals icons indicating peers' recent interactions and a playhead icon to navigate through updates. This feature fosters awareness of ongoing collaborations, encourages user engagement, and offers a dynamic way to explore collaborative content.

Collectively, these components empower Syncboard to address social isolation by providing a versatile platform for creative collaboration, interactive gameplay, and asynchronous interactions. Syncboard aims to enrich users' lives by fostering connections, creative expression, and social well-being - all on a platform with the potential to fulfil multiple roles, functional or aesthetic, within a home environment **(Figs 6.22 & 6.23)** .

Fig 6.23 - An in-situ representation of Syncboard in a kitchen environment.

Chapter 7. Discussion

In this chapter, the insights gathered from the workshop discussions and prototype testing questionnaires and interviews are discussed. These resources provided a comprehensive understanding of participants' experiences and views on social isolation and the proposed socio-technical intervention prototypes.

7.1 Themes and Experiences

The workshops and prototype test phases revealed a range of key themes and patterns regarding the experiences and perceptions of participants.

7.1.1 Diverse Perceptions of Social Isolation

The workshop data provided valuable insights into the wide range of perceptions surrounding social isolation **(3.1, 3.2, & 3.3)**. Participants openly shared their individual experiences, offering a window into the various situations and circumstances that triggered feelings of loneliness and isolation. Throughout the workshops, participants shared stories that consistently highlighted demanding work schedules, long-term illness, and the challenges of remote living or social disconnection as common causes of social isolation **(3.2.1)**. These narratives illuminated the difficulties of sustaining regular social interactions in the face of such demands.

One participant's story resonated with many: the struggle to balance a demanding job and familial responsibilities with the need for social connection, underscoring the delicate equilibrium that many participants sought to achieve. These personal narratives also unveiled the many ways in which social isolation affects individuals, emphasising the significant physical, mental, and emotional toll it can have on their well-being (see **3.2.2**). Emphasis was given to the issue of monotony and boredom - widely regarded as one of the most prevalent maladies caused by social isolation, and one given notable importance when looking into intervention concepts.

The data analysis from prototype testing interviews in **Chapter 5** also echoed the notion that social isolation is not a one-size-fits-all concept. Participants shared their experiences, with some highlighting the importance of deeper, more meaningful connections over the mere frequency of social interactions **(5.3.2)**. These insights emphasise the intricacies of individuals' perceptions of and responses to social isolation, underscoring the need for tailored interventions that account for this diversity.

7.1.2 Seeking Innovative Solutions

Participants displayed a keen interest in innovative interventions for combating social isolation, as evident from their diverse and imaginative ideas outlined in **Chapter 4** and their detailed feedback during prototype testing discussions highlighted in **Section 5.3**. Their receptiveness to technological solutions was apparent throughout the workshops, where they proposed novel approaches using emerging technologies like virtual reality, artificial intelligence, and digital platforms to bridge physical distances and foster digital connections, as documented in the Catalogue of Intervention Concepts **(4.1)**.

During the prototype testing phase, participants engaged enthusiastically with the socio-technical solutions, leading to predominantly positive feedback **(5.3.1)**. This enthusiasm, supported by questionnaire analysis **(5.2)**, and insightful one-on-one interview discussions (**5.3**), underscores their readiness to embrace novel technological interventions to alleviate loneliness and social isolation. The alignment between their creative ideas, technological openness, and positive testing outcomes highlighted the potential of leveraging innovative socio-technical solutions to address contemporary social challenges.

7.1.3 Synchronous vs. Asynchronous Dynamics

As discussed in **Section 5.3.3**, the synchronous and asynchronous designs evoked different responses among participants. The synchronous Social Circles prototype received praise for its structured events and real-time interactions, effectively fostering meaningful connections and reducing isolation, especially during non-traditional social hours **(5.3.3)**. In contrast, the asynchronous Syncboard prototype, while less effective in promoting substantial social

interactions, was valued as a creative and therapeutic distraction, particularly by those with creative interests **(5.3.1** & **5.3.2)**. It provided relief from isolation and served as an outlet for self-expression without the pressures of intensive social activity. Participants found unique ways to bond and communicate with friends through creative collaboration, offering a sense of satisfaction and accomplishment **(5.3.5)**. As one of the participants in the testing stated:

> *"Being able to get creative and collab with friends was a new one for me*
> *and gave us something new to bond over."*
> - Quote from participant #G008 during post-testing discussions on Syncboard.

The design allowed friends to find new ways to bond and communicate at times when typical in-person socialisation was difficult or stressful. The collaborative creativity that the design represented also gave users an opportunity for feelings of satisfaction and accomplishment, both commonly associated with positivity, as identified in **5.3.5** during post-testing interviews. These findings align with existing research that shows creative and therapeutic outlets have long-term merit in reducing feelings of isolation (Cattan, White and Bond, 2005; Goncarlo *et al.*, 2021), as well as strategies identified by Hwang et al. (2020) to combat social isolation, including emotional and psychological management and maintaining social connections. In **5.3.3**, participants identified that Social Circles excelled in sustaining social connections, while Syncboard's asynchronous design contributed to emotional and mental well-being. This highlights the importance of offering diverse interaction options and suggests potential benefits in combining synchronous and asynchronous models.

7.1.4 Personality-Driven Engagement

The analysis of both prototype testing questionnaires **(5.2)** and interviews **(5.3)** highlighted the significant influence of participants' personalities on their engagement with the prototypes. Extroverted participants naturally gravitated toward designs that supported spontaneous and frequent social interactions, aligning with their sociable nature **(5.3.4)**. Extroverts frequently used Social Circles for impromptu conversations and spontaneous interactions, reporting positive outcomes such as reduced isolation and improved emotional

well-being during interviews **(5.3.5)**, despite marginal changes in calculated metrics for satisfaction and engagement **(5.2.4)**.

In contrast, introverted participants valued the prototypes for their ability to provide controlled and measured activities, creating a low-pressure environment for engagement **(5.3.4)**. The interventions yielded the most significant improvements and benefits for introverted individuals, indicating that they represent a promising and receptive target audience for socio-technical interventions aimed at addressing social isolation **(5.2.4)**. They appreciated features that allowed them to assess their mood before participating in social activities and granted them independent control over their social visibility. Post-testing interviews revealed a shared desire among both personality groups for increased control over their social connections, with participants from both extroverted and introverted backgrounds requesting enhancements to availability modes for Social Circles and collaboration options for Syncboard **(5.3.4)**.

These participant experiences underscored the importance of designing for diverse personality traits. Findings suggest that Extroverted individuals prefer prototypes encouraging spontaneous interactions, while introverts appreciated designs that offer control over engagements, allowing them to navigate interactions at their own pace and comfort.

7.1.5 Long-Term Impact and Adoption Hurdles

Participants expressed hope for the long-term impact of the prototype designs in alleviating social isolation during the workshop discussions and interviews **(5.3.2)**, impressions that align with existing literature, reinforcing the hypothesis that socio-technical solutions can be used to combat social isolation effectively (Duffy *et al.*, 2018). Participants also recognised significant challenges to achieving widespread adoption, as highlighted in **5.3.5**, shedding light on potential obstacles to the sustained effectiveness of these interventions.

Sustaining user engagement emerged as a challenge for both prototype designs, along with maintaining a substantial user base **(5.3.6)**. Participants consistently emphasised the importance of building a critical mass of users to create a vibrant and active community

around these interventions, which also aligns with the literature's emphasis on critical user mass and consistently available support networks (Card and Skakoon-Sparling, 2023).

Concerns about user motivation and interaction frequency were echoed throughout the interview discussions **(5.3.5)** and further elaborated in **5.3.6**. Usability issues, particularly related to Syncboard's functionality options and interface complexity, were prominently featured in participants' feedback, leading to hesitation in engaging consistently with the platform. One participant's experience, captured in the quote below, illustrates these usability challenges:

> *"The only drawing program I've used before is Windows Paint, so the stuff on Magma was pretty overwhelming. Took me a while to get used to the basics, and I didn't use most of it."*
> - Quote from user #B033 from post-testing interview regarding Syncboard.

These findings underscore the intricate nature of the challenges associated with the long-term impact and adoption of interventions targeting social isolation. The emphasis on affordability and accessibility aligns with existing literature, which highlights the importance of addressing these factors in designing effective socio-technical solutions. The issue of sustaining engagement complements previous discussions on personality-driven engagement and the need to cater to diverse user preferences, providing a deeper understanding of the barriers that such interventions may encounter. By examining these adoption hurdles within the context of sustaining engagement, future studies can delve into the complex dynamics involved in addressing social isolation through innovative socio-technical interventions.

7.2 Comparison to Previous Studies

This section contextualises this research project within the broader landscape of studies addressing social isolation and loneliness interventions, with a particular focus on socio-technical approaches. Through a comparative analysis of previous research, including their outcomes, methodologies, and limitations, this section aims to elucidate the unique contributions of this study to the wider field.

7.2.1 Addressing the Continuum of Isolation

The findings of this study aligned with previous research emphasising the detrimental impact of social isolation on mental health, as highlighted by studies investigating the comorbidities associated with long-term social isolation (Benke *et al.*, 2020; Grover *et al.*, 2020; Sigdel *et al.*, 2020). While these studies primarily focused on the co-occurrence of anxiety and depression, the results from this project's workshops **(3.2.1)** revealed the broad spectrum of symptoms and challenges individuals have faced when dealing with social isolation.

This research project also took a more inclusive approach by exploring a wider range of individuals susceptible to isolation, not limited solely to the elderly, a limitation identified by other studies (Baker *et al.*, 2018). By expanding the pool of test subjects to encompass various age groups, demographics, and economic situations, the project supports the hypothesis that people from a diverse array of backgrounds can experience significant social isolation issues (Luhmann and Hawkley, 2016). The diverse experiences gathered from the workshop groups contribute to a more comprehensive understanding of the varied nature of isolation and the development of future interventions.

7.2.2 Efficacy of Socio-Technical Interventions

This research project operated within the evolving landscape of socio-technical interventions aimed at addressing the complex issue of social isolation. The overall user testing displayed noticeable improvements in the frequency and quality of social activity due to the interventions **(5.2.1**, **5.3.1**, **5.3.2),** which aligns with the findings of Burholt et al. (2020) that technological solutions have significant potential in mitigating social isolation.

Social Circles, with its focus on structured social events and synchronous interactions, had a structure in alignment with studies emphasising the benefits of regular socialisation events for combating social isolation (Cattan, White and Bond, 2005; Duffy *et al.*, 2018).

Syncboard, serving as a collaborative art and meditative therapy tool, corresponded with literature highlighting the value of creative outlets for emotional and mental well-being (Goncarlo *et al.*, 2021).

However, this project also underscored the importance of understanding how personal preferences and life experiences shape the effectiveness of these interventions, in line with Burholt et al.'s (2020) assertion that interventions must be tailored to individual needs and expectations. While this study has shown that socio-technical tools have promise in mitigating social isolation, the effectiveness of these interventions can vary. A significant factor directly related to the use of technological tools, is the prior familiarity of the user with those tools (Burholt *et al.*, 2020) - an implication that will be discussed further in **7.4.3**.

Building upon this understanding, this research project navigated the complexities of socio-technical interventions by exploring a range of technological tools and solutions. It recognised the need to move beyond traditional paradigms, such as standard social networking tools, and explored emerging technologies that cater to the evolving needs and preferences of individuals susceptible to social isolation. This approach aligned with the call for a broader scope in researching socio-technical interventions, one that encompasses diverse populations and contexts, as advocated by Baker et al. (2018).

As part of this approach, the prototype concepts proposed in this study underwent iterative refinement stages, guided by invaluable user feedback **(5.3.5 & 5.3.6)**. These iterations resulted in the streamlining and simplification of user interface elements - outlined throughout **Chapter 6** - with the overarching goal of making the tools as user-friendly as possible for a wide range of individuals. This meticulous design process aimed to ensure that the interventions were not only effective in combating social isolation but also accessible and accommodating to the unique preferences and technology familiarity of the users.

Furthermore, this research project acknowledges that the experience of isolation is highly diverse and influenced by a range of factors, such as age, personality traits, and economic status, as highlighted by Mund and Neyer (2019), Buecker et al. (2020), and Card and Skakoon-Sparling (2023). There is a growing consensus that interventions should not only aim to alleviate isolation but should also facilitate the formation and sustenance of supportive social networks, an approach which aligns with the goal of addressing the continuum of isolation, encompassing a broad range of individuals and scenarios.

In conclusion, this research project delved into the dynamic realm of socio-technical interventions, driven by the recognition of technology's potential to combat social isolation. By embracing a diverse array of technological solutions, accounting for technology familiarity, and adapting to the unique experiences of individuals, this research aimed to contribute significantly to the ongoing discourse on effective socio-technical interventions for addressing social isolation.

7.2.3 Filling the Gaps in Research

The current literature acknowledges the scarcity of well-evaluated interventions for loneliness, particularly in the field of HCI (Waycott *et al.*, 2016; Baker *et al.*, 2018). This scarcity is compounded by the limited scope of many studies, which often focus primarily on specific sub-groups, such as the elderly. This study aligned with these observations and proposed a path to fill these research gaps by focusing on socio-technical interventions that are not limited to elderly populations. Instead, it sought to explore interventions with the potential for broad applicability across diverse demographic and economic groups. By expanding the research scope to encompass a wider demographic, this study aimed to contribute to understanding whether specific intervention styles are more beneficial for diverse groups in distinct contexts.

The review of existing studies also highlighted a prevailing trend of social networking applications dominating the landscape of socio-technical interventions, with the critical analysis of these interventions suggesting the need for exploration of alternative socio-technical solutions (Baker *et al.*, 2018). This research extended this argument, asserting that a lack of diversity in intervention modalities hampers the ability to effectively address the complexities of social isolation. By advocating for the exploration of emerging technologies and novel interaction methods, this study contributed to diversifying the toolkit of intervention strategies, aiming to develop a more comprehensive and effective approach to combating social isolation across various populations and settings.

7.2.4 Critical Evaluation of Previous Research

The review of the literature highlighted the urgent need for rigorous evaluations and standardised reporting practices within the field of social isolation interventions (Dickens et al., 2011; Fakoya, McCorry and Donnelly, 2020). This study was keenly aware of these concerns and placed paramount importance on employing robust and comprehensive evaluation methods.

Moreover, the research recognised the potential limitations of one-on-one interventions and draws insights from previous studies to advocate for the effectiveness of group-based interventions with specific focuses, a concept illustrated by Cattan et al. (2005). It also underscored the significance of expanding and sustaining potential support networks, an idea supported by the work of Swickert et al. (2002).

In summary, this research made a significant contribution to the growing body of literature by adopting a comprehensive approach to understanding social isolation interventions. By transcending conventional demographic boundaries and embracing a diverse array of technological solutions, this study sought to enrich the arsenal of available interventions and comprehensively address the multifaceted challenges posed by social isolation.

7.3 Limitations

7.3.1 Remote Research Interaction

Due to the researcher's ongoing health issues, in-person interactions with participants and the organisation of in-person group meetings were not possible. Instead, all discussions were conducted using online communication tools. The prototypes selected for this project were specifically chosen for their suitability for remote or in-home testing. This approach, while necessary, may have influenced the depth and richness of the data collected. Face-to-face interactions have the potential to offer additional insights and nuances that could enhance the understanding of participants' experiences and perspectives.

7.3.2 Participant Pool and Recruitment Bias

This study had a relatively small participant pool, particularly for the testing and evaluation of design prototypes. The constrained participant pool resulted from health-related limitations that prevented large-scale testing procedures. While the data obtained from this sample provided indicative insights, a larger and more diverse participant pool would have contributed to more robust data and a wider range of perspectives. Doing so could potentially broaden the applicability of this study's findings, in line with the findings of existing literature (Baker *et al.*, 2018; Fakoya, McCorry and Donnelly, 2020).

The recruitment strategy also introduced potential biases. Participants were volunteers who responded to advertisements on shared communication or social media channels. This recruitment approach may have favoured specific demographics such as age, ethnicity, education, and personality types. Consequently, the study's findings may not fully represent the experiences and viewpoints of the entire population. To mitigate this limitation, future studies should endeavour to diversify the testing pool by employing more varied recruitment strategies and drawing participants from a broader range of sources.

As shown in **5.2.4,** another significant limitation involved the relationship between personality type, and baseline social engagement and satisfaction metrics. While the study results indicated that personality type, particularly introversion, had a significant impact on the efficacy of interventions, the limited size of the participant pool meant that an in-depth analysis of whether this impact was influenced by the existing levels of social isolation and loneliness the participant may have been suffering from. Further studies directed toward this goal would be recommended, in order to further tailor future interventions.

Another limitation, shown in **5.2.2** and **5.2.3**, was the unexplained existence of significantly large standard deviations. While this variance may be partially explained by the comparative findings of introversion vs. extroversion, there could have been other variables at play. such as the impact of demographics, backgrounds, and life experiences. Further testing, utilising a wider pool of subjects, would be recommended in order to gather enough data for in-depth statistical analysis across as many demographics as possible.

7.3.3 Cost Limitations and Prototype Development

Budget limitations played a significant role in this research project, impacting the depth and scope of prototype development. These constraints compelled the project team to find creative ways to design and develop the prototypes with the available resources. As a result, certain compromises were made in terms of prototype complexity and customisation.

To make the most of limited resources, existing technologies and platforms were adapted and modified to align with the project's objectives. While this approach enabled prototype development, it also meant that the final designs might not have been as tailored or specialised as they could have been with more extensive resources. Additionally, extraneous features, especially within the Syncboard demonstration, added unnecessary complexity to the user interface and experience.

Budget limitations also led to the creation of simplified versions of the proposed prototypes, capturing core concepts and interactions while minimising the need for extensive development. While this facilitated the exploration of design concepts, it may have limited the full realisation of certain features and functionalities. The digital-only demonstration models, while functional, could not fully emulate the intended physical objects that would exist in the user's world as a consistent prompt for social engagement. In practice, a compromise could have involved delivering mock-up physical items alongside the digital demonstrations, but cost and time constraints made this infeasible.

With additional funding, the project could have potentially enlisted professionals with specialised expertise in design, HCI, and software development. This might have resulted in more bespoke solutions that comprehensively address the unique challenges posed by social isolation.

Despite these budget limitations, the insights gained from prototype testing and user feedback remain valuable. The constraints provided an opportunity for innovation, creativity, and resourcefulness, resulting in the development of prototypes that, while not exhaustive, offer indicative insights into the potential of HCI interventions for mitigating social isolation. Future research endeavours, with increased funding and resources, could explore more

intricate and specialised design solutions to comprehensively address the challenges of social isolation.

7.3.4 Time Constraint for Prototype Testing

There were time constraints inherent to the prototype testing phase, where each group had a one-week testing period due to participant scheduling. A longer testing period could provide a more comprehensive understanding of how the HCI prototypes affect social isolation metrics over time. It would also enable a deeper analysis of the interventions' effectiveness and sustainability. Additionally, a lengthier duration could have revealed whether observed changes in social metrics reached a plateau or returned to baseline levels, shedding light on the long-term impact and stability of the interventions. While the current procedures yielded valuable insights, the time constraint limited the exploration of the full range of effects and dynamics. Future studies should consider allocating a more extended testing period to conduct a more nuanced evaluation of the social encouragement tools.

7.3.5 Limited Geographic Representation

The participant pool for this study was exclusively drawn from the United Kingdom. Therefore, the findings derived from this sample may not be fully applicable to other countries or regions. Parts of the co-design workshops focused on pandemic experiences, drawn from isolation during quarantines and lockdowns. It is important to acknowledge that the unique cultural, social, and healthcare systems of the United Kingdom might have shaped participants' insights and suggestions, potentially neglecting valuable perspectives from individuals in different geographic contexts. The lack of geographical diversity may have hindered the identification of coping strategies and resources that are effective across more diverse cultural settings.

7.3.6 Comparison with Traditional Social Interventions

This study concentrated exclusively on the interaction between participants and socio-technical interventions. One notable limitation is the absence of a direct comparison

between the use of HCI interventions and traditional, non-technical social interventions. This limitation arises from the study's scope, constraints, and primary emphasis on exploring the potential of HCI-based solutions. Consequently, there exists a gap in knowledge regarding the relative effectiveness of these technological interventions compared to conventional non-technical strategies that encourage and facilitate social engagement.

7.3.7 Limitations Summary

These limitations, encompassing remote research interactions, budget constraints, a limited participant pool, and the absence of a direct comparison with traditional social interventions, have implications for the breadth and depth of the study's findings. Recognising and addressing these limitations in future research endeavours can contribute to a more comprehensive understanding of the potential of HCI interventions in alleviating social isolation across diverse individuals and contexts.

7.4 Implications and Future Research Directions

This section examines the broader implications of the study's findings and discusses potential applications in both practical and theoretical contexts. It also highlights future research directions based on the key themes and patterns identified in the analysis and discussion chapters.

7.4.1 Tailored Interventions for Diverse Demographics

This study's findings underscore the importance of designing interventions that accommodate diverse personality traits and user preferences. Synchronous designs, like Social Circles, are effective for real-time interactions, structured events, and spontaneous social encounters, factors appreciated by extroverted users **(5.3.4)**.

Asynchronous designs, exemplified by Syncboard, provide creative outlets and therapeutic engagement, aligning with the' preferences of introverted participants, as well as those with creative interests **(5.3.3)**. Participants suggested tailoring Syncboard further towards these roles **(5.3.5)**, in line with the concept of personalised interventions discussed in the literature

(Burholt *et al.*, 2020; Fakoya, McCorry and Donnelly, 2020)). These insights emphasise the desire for multifaceted interventions that cater to a spectrum of social needs, personalities, and individual interests.

Moreover, this research goes beyond the prior predominant focus on the elderly demographic (Reedman-Flint et al., 2022) and recognised the unique needs and experiences of a more diverse and generalised population. Consequently, recommendations for future research include that interventions should be customised to accommodate the preferences, technological familiarity, and social contexts of various groups. This recognition sets the stage for interventions that are sensitive to the distinct factors influencing social isolation across a broad spectrum of individuals. Furthermore, there is a need for further investigations into the complex interplay between personality traits, engagement patterns, and mental health outcomes to better understand the dynamics of social isolation and understand how interventions can be tailored to fulfil individual needs.

7.4.2 User-Centric Approach to Technology Design

This study underscored the value of adopting a user-centric approach to technology design, focusing on users' psychological well-being and individual preferences. Understanding how people of different demographics, backgrounds, preferences, and personality types engage with and respond to digital interventions is crucial for developing platforms that enhance social engagement while considering individuals' comfort levels and emotional needs. The findings also emphasised the importance of incorporating customisation options, intuitive interfaces, and mechanisms for privacy and control to create a positive user experience.

7.4.3 Addressing Challenges for Adoption and Engagement

The challenges identified in this study, such as sustaining user engagement and addressing usability concerns, provided valuable insights for the development of future interventions and align with key themes identified in the literature review and data analysis. A substantial user base is essential for the success of interventions like Social Circles and Syncboard, reflecting the importance of social support networks (Swickert *et al.*, 2002; Cattan, White and

Bond, 2005). Sustaining user engagement over time, as seen in long-term impact studies (Waycott *et al.*, 2016; Burholt *et al.*, 2020), is a common challenge. Participants also highlighted accessibility and affordability as potential barriers during prototype testing discussions **(5.3.6)**. Cross-platform solutions, where more limited but more affordable app-based variations can still interact with the more advanced physical products, may be a valuable pathway for potential future development projects.

Another significant factor limiting the efficacy of technological interventions, recognised by Burholt et al. (2020), is the familiarity of individuals with the technology in use. For instance, individuals over the age of 75, who may have limited familiarity with modern technologies, responded less favourably to interventions that utilised those technologies (Burholt *et al.*, 2020). This highlights technology familiarity as a crucial variable when designing socio-technical interventions. While this limitation may be more pronounced in older demographics, the broader implication is that personal preferences, experiences, and familiarity with technology can significantly influence the impact of interventions across various demographics and contexts.

7.4.4 Advancing Socio-Technical Interventions

This study highlights the potential of socio-technical interventions to alleviate social isolation and foster a sense of connectedness. By considering participants' technological familiarity and recognising the influence of individual preferences on intervention effectiveness, this research underscores the need for interventions tailored to individuals' technological backgrounds. This insight carries substantial implications for the design and implementation of future interventions, emphasising the importance of user-centric approaches that consider participants' comfort and proficiency with modern communication tools.

Furthermore, conducting longitudinal studies to track the impact of prototype interventions over extended periods could offer valuable insights into their sustained effectiveness and long-term benefits.

The primary implication of this research lies in its contribution to addressing gaps in the existing literature concerning social isolation interventions. By advocating for research that extends beyond elderly populations (Reedman-Flint *et al.*, 2022), and placing emphasis on comprehensive evaluations (Dickens *et al.*, 2011), this study strives to provide a more comprehensive perspective on effective interventions. Recognising the limitations and gaps in prior research underscores the importance of rigorous evaluations while encouraging future studies to explore emerging technologies and novel solutions aligned with contemporary communication trends.

7.4.5 Potential for Hybrid Solutions

Efforts to enhance accessibility and engagement with intervention designs have sparked interest in hybrid or multi-purpose solutions. The findings from this study, as discussed in **Section 7.1.1**, suggest that hybrid solutions seamlessly integrating both synchronous and asynchronous elements may hold promise. Such a platform could offer a diverse range of interaction modes, catering to different user needs and preferences, resulting in comprehensive and adaptable interventions. This approach also recognises that individuals may shift between introverted and extroverted states based on context, mood, or various personality traits, and so a solution that has features or options that are tailored towards both traits would allow for wider and more consistent applicability.

Additionally, another avenue for hybridisation involves integrating both digital and physical designs. Although the interventions demonstrated in this study primarily relied on existing digital platforms due to time and cost constraints, the original conceptual design goals aimed at creating physically tangible socio-technical interventions. Future research could expand on this concept and explore more tangible interventions, assessing whether they offer advantages in mitigating social isolation compared to purely digital alternatives. This approach can lead to the application of cross-platform solutions, exploring any beneficial impacts of physical solutions, while still leveraging the cost-saving and accessibility benefits of digital platforms.

Examining the interplay between online and offline interactions, especially in the context of hybrid solutions, could also yield a deeper understanding of how digital interventions influence real-world relationships and social dynamics. Furthermore, research into the potential benefits of combined-arms solutions that utilise both synchronous and asynchronous styles of interaction could be highly beneficial, as it would allow for a more comprehensive approach to addressing social isolation across diverse scenarios and for individuals with various personality traits.

It is also essential to acknowledge that non-technical solutions currently play a significant role in addressing social isolation. Therefore, future research should consider conducting rigorous comparative studies, such as randomised controlled trials, where participants are assigned to receive either HCI-based interventions or traditional interventions. Outcome measures should encompass changes in loneliness levels, mental health indicators, and overall well-being, to determine if socio-technical interventions have tangible benefits over non-technical solutions. Additionally, research should investigate whether a combination of HCI and traditional interventions yields superior results, leveraging the strengths of both methods to provide comprehensive support for individuals experiencing social isolation.

7.4.6 Collaboration with Mental Health Professionals

Future work on socio-technical interventions could be strengthened by including relevant mental health professionals in the co-design and testing phases of development. By collaborating with mental health experts, interventions can incorporate evidence-based strategies for enhancing social interactions and combating feelings of loneliness. Such collaborations can also provide mechanisms for identifying individuals who may require additional support or those who would benefit most from specific approaches. This interdisciplinary approach can enhance the overall effectiveness of interventions and ensure that they are grounded in scientific research and best practices.

Chapter 8. Summary and Concluding Thoughts

This investigation was guided by a set of key research questions, each shedding light on a specific aspect of social isolation and offering potential solutions.

Research Question 1: Causes, Outcomes, and Coping Mechanisms

Exploration began by delving into the causes, outcomes, and coping mechanisms associated with social isolation. It revealed the diverse experiences of individuals facing social isolation, driven by factors ranging from demanding work schedules to the emotional toll of long-term illness. The outcomes were just as diverse, encompassing a wide spectrum of psychological and emotional distress, exacerbated by pervasive feelings of boredom and monotony. These perspectives highlight the necessity of multiple intervention styles, tailored towards counteracting a variety of causations and outcomes.

- See **3.2.1, 3.2.2, 7.1.1.**

Research Question 2: Resolving Gaps in Existing Research

This project examined the shortcomings and gaps in current research on social isolation. These flaws have been well-documented in the literature, with many intervention studies inadequately addressing the intricacies of isolation due to a focus on social media-based interventions targeted at limited target populations. This study expanded upon this by exploring how more varied socio-technical designs could fill these gaps, studying the effects among broad pools of participants. The user-centric approach in this study recognised the potential of modern technology in addressing social isolation, where digital tools were seen to play a vital role in bridging social gaps and mitigating isolation induced monotony.

- See **2.8.2**, **3.2.3**, **7.2.3**.

Research Question 3: Impactful Factors

A significant factor that was identified was how extroverted and introverted personality types had significant impacts on the efficacy of socio-technical interventions. Findings revealed that introverts in particular showed significant improvements and beneficial outcomes from

these interventions, emphasising the importance of accommodating preferences related to personality traits in intervention design.

The preexisting interests and experiences of intervention users also played a significant role. Users of Syncboard, a tool primarily centred around artistic expression, showed greater enthusiasm for the design when they had preexisting creative interests, which led to increased engagement and overall effectiveness.

- See **3.2.4**, **5.2.4**, **5.3.3**, **5.3.4**, **7.1.4.**

Research Question 4: Socio-Technical Solutions

A range of socio-technical solutions were proposed to address the unique needs of individuals experiencing social isolation. Co-design workshops yielded intervention concepts encompassing real-time interactions, asynchronous engagement, and a spectrum of technological tools, from existing digital platforms to theoretical emerging technologies. Notably, there was a recurrent preference for exploiting artificial intelligence to automate and/or streamline the mitigation of social isolation. These findings underscore the potential of socio-technical interventions, only limited by the imagination of the creators.

- See **Chapter 4** and **Chapter 6**.

Research Question 5: Engagement and Benefits

The study proceeded to investigate participants' engagement with, and the benefits derived from, socio-technical interventions. The reception was promising, demonstrating that participants were receptive to the use of innovative technological solutions for alleviating loneliness and social isolation. The beneficial outcomes of these interventions were also promising, showing significant improvements to the frequency and quality of social engagements, and reductions in feelings of boredom and monotony. These results and accompanying feedback highlighted the potential of HCI interventions in the effective mitigation of the effects of social isolation.

- See **5.2**, **5.3**, **7.1.2**, **7.1.3**.

Research Question 6: Comparison of HCI Designs

This study assessed the effectiveness of synchronous and asynchronous HCI designs in improving the frequency and quality of social engagement. The findings indicated that both approaches offered unique advantages, with outcomes highlighting the complex interplay between personality traits, individual interests, and design preferences. Additionally, each solution exhibited distinct benefits, contingent on the specific circumstances and symptoms experienced by individuals facing social isolation. Notably, synchronous solutions were more beneficial for extroverted individuals seeking increased real-time social interactions, while asynchronous solutions were deemed more useful for alleviating boredom, fostering low-pressure social contact, and addressing general monotony. These results emphasise the importance of tailoring intervention usage to individual situations and preferences.

- See **5.2.2**, **5.2.3**, **5.3.3**, **7.1.3**, **7.1.5**.

Research Question 7: Effective Design Elements

In the quest to determine which design elements were most effective in addressing social isolation needs, valuable insights were uncovered. The importance of user-centric design, customisation options, intuitive interfaces, and mechanisms for privacy and control emerged as key factors in creating a positive user experience. Tailoring design concepts towards specific needs, preferences and demographics also have significant benefits. Developing interventions based on art or music for those with a creative background, for example, would ensure the design has multiple beneficial roles and a greater chance of engagement.

- See **5.3.3**, **5.3.5**, **5.3.6**, **7.1.3**, **7.1.4**, **7.1.5, 7.4.1**.

Future Directions

As this research project reaches its conclusion, it becomes evident that there are numerous avenues for further exploration. Future research endeavours could focus on conducting rigorous comparative studies that systematically compare HCI-based interventions to traditional non-technical approaches. Additionally, investigating the potential benefits of

combined-arms solutions that utilise both HCI tools and traditional interventions could offer a more comprehensive approach to addressing social isolation.

Longitudinal studies tracking the sustained effectiveness of these interventions over time, as well as exploring the interplay between personality traits, engagement patterns, and mental health outcomes, are essential for gaining a deeper understanding of the complex dynamics involved in mitigating social isolation.

- See **5.3.5**, **5.3.6**, **7.2**, **7.4**.

Concluding Thoughts

This research has contributed valuable insights into the nuanced ways individuals engage with and respond to HCI-based interventions aimed at addressing social isolation. These findings underscore the importance of tailoring interventions to accommodate varying personality traits and preferences, as well as the need for strategies that foster lasting impact and adoption. The findings also highlighted the potential of socio-technical interventions to mitigate loneliness, and the boredom and monotony that often accompanies social isolation.

The implications of this research extend beyond academia, offering practical insights into the design of interventions that cater to the unique needs of diverse demographics. By focusing on user-centric approaches, addressing engagement challenges, and accounting for the influence of personal preferences and familiarity with technology, this study has paved the way for more effective interventions in the ongoing battle against social isolation. As this research moves forward, it is important to continue to collaborate with experienced individuals, uphold ethical considerations, and explore hybrid solutions that integrate the strengths of both synchronous and asynchronous interaction modes.

The journey is far from over. The path ahead involves further research, innovation, and collaboration to harness the potential of technology in combating social isolation, ultimately fostering a world where meaningful connections thrive.

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Appendices

Appendix 1.1 - PROMIS Social Isolation Scale

Please respond to each item by marking one box per row.
Never / Rarely / Sometimes / Usually / Always

1. I feel isolated even when I am not alone.
2. I feel detached from other people.
3. I am satisfied with the amount of time I spend interacting socially with my friends.
4. People get the wrong idea about my situation.
5. I feel that some of my friends avoid me.
6. I feel that some of my family members avoid me.
7. I feel left out.
8. I feel that people barely know me.
9. I feel isolated even when I am not alone.
10. I feel that people are around me but not with me
11. I feel that I am no longer close to anyone.
12. I feel that I am alone in my interests and ideas.

Appendix 1.2 - LUBBEN SOCIAL NETWORK SCALE – 18 (LSNS-18)

FRIENDSHIPS: Considering your friends…

1. How many of your friends do you see or hear from at least once a month?
0 = none 1 = one 2 = two 3 = three or four 4 = five thru eight 5 = nine or more

2. How often do you see or hear from the friend with whom you have the most contact?
0 = less than monthly 1 = monthly 2 = few times a month 3 = weekly 4 = few times a week 5 = daily

3. How many friends do you feel at ease with that you can talk about private matters?
0 = none 1 = one 2 = two 3 = three or four 4 = five thru eight 5 = nine or more

4. How many friends do you feel close to such that you could call on them for help?
0 = none 1 = one 2 = two 3 = three or four 4 = five thru eight 5 = nine or more

5. When one of your friends has an important decision to make, how often do they talk to

you about it?

0 = never 1 = seldom 2 = sometimes 3 = often 4 = very often 5 = always

6. How often is one of your friends available for you to talk to when you have an important decision to make?

0 = never 1 = seldom 2 = sometimes 3 = often 4 = very often 5 = always

LSNS-R total score is an equally weighted sum of these twelve items. Scores range from 0 to 30

Appendix 1.3 - NIH Social Relationship Scale

Instruction Set for Companionship (Friendship / Loneliness) items:

For the next set of questions, please read each statement and then decide how much each applies to you in the past month.

In the past month, please rate how often…

Friendship

1. I get invited to go out and do things with other people
2. I have friends I get together with to relax
3. There are people around with whom to have fun
4. I can find a friend when I need one
5. I feel like I have lots of friends
6. I have friends who will have lunch with me when I want
7. I feel close to my friends
8. I feel like I'm part of a group of friends

Loneliness

1. I feel alone and apart from others
2. I feel left out
3. I feel that I am no longer close to anyone
4. I feel alone
5. I feel lonely