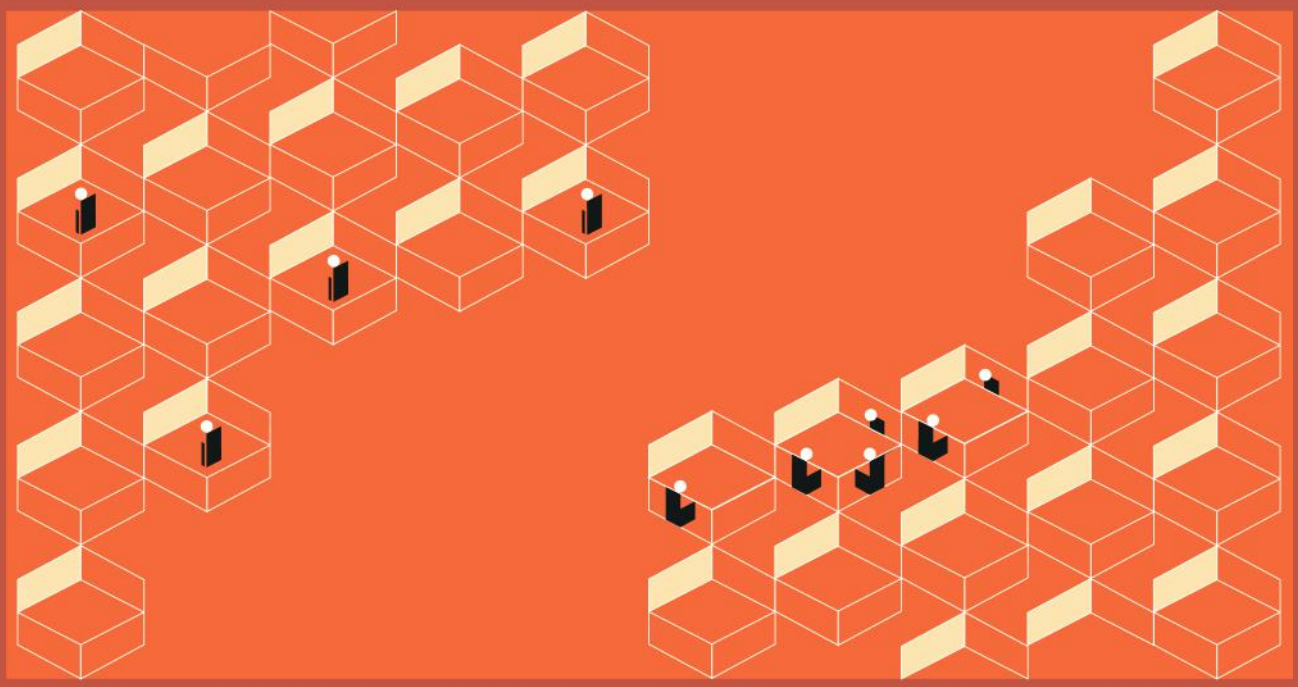

Designing Interactive Public Displays for Social Interaction among Nursing Home Residents

Kai Kang

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PROEFSCHRIFT

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Summary

Positive peer relationship in nursing homes is an important component of residents' life quality. However, social interaction between residents is found to be limited, and their relationships are difficult to establish. In past decades, conventional social interventions have changed very little and had limitations. Although many studies have proved that interactive public displays (IPD) can socially connect people in one community, designing for nursing homes is challenging due to the lack of supported knowledge. My PhD research investigates how to design appropriate IPD to enhance nursing home residents' social interaction and wellbeing. Research-through-Design is adopted to generate knowledge through an iterative process of developing experimental systems in real-life settings. A series of studies were conducted with an overall research question:

How to design IPDs in nursing homes to promote social interaction among residents?

This question can be answered by addressing the challenges from the perspectives of design factors, user interaction, social impact, and design methods, thus dividing it into four research questions, which are:

RQ1: *Which factors should be considered when designing and deploying IPDs to promote social interaction among nursing home residents?*

RQ2: *To what extent can nursing home residents accept and engage with IPDs?*

RQ3: *To what extent can IPDs influence nursing home residents' social lives?*

RQ4: *How to involve nursing home residents to contribute to the design of IPDs for their social interaction?*

The whole PhD research can be summarized as follows:

The research commenced with a factor-finding design project. Via an explorative design case 'OutLook', we aimed to gain initial insights into the social potential of IPD in nursing homes and how to design appropriate IPD for this context. OutLook is a series of gallery-like displays that aims to enhance residents' social interaction and feelings of connectedness by continuously demonstrating shared images of real-time views and trigger further communications through a 'postcard-sending' metaphor. To design OutLook, conventional design methods were adopted, including informal observations, interviews, and brainstorms. After the implementation, a six-week field trial was performed to assess the influence of OutLook on residents' behavior via structured observations before and after the deployment. The field trial ended with semi-structured interviews to investigate residents' subjective feelings. It was found that most related social interactions took place after the residents left the area. Such conversations were superficial and hardly sustainable. While most interviewed participants felt connected to the shared views, few felt connected to other people. The results indicated that OutLook could promote their social interaction and connectedness to some extent, but still has a lot of room for improvement. Key design factors and lessons learned were proposed.

Guided by the case of OutLook, a contextual study was conducted with twenty-one residents from two nursing homes. The objective was to deeper understand residents' social preferences and demands by investigating their preferred media products in public spaces and private rooms, their preferred genres and topics, and their current related social scenarios and barriers. Based on this understanding, three design strategies were proposed: *1. Augment residents' experience of existing media habits. 2. Introduce new media products/systems with residents' preferred genres. 3. Establish platforms for residents to share their personal media products*. These strategies aimed to influence residents' social status to different degrees. It was hypothesized that the first strategy could be an ideal solution to start because it has the lowest learning cost, and related genres such as news, life, and activities in nursing homes would be effective in improving the quantity of residents' social interaction. The second and third strategies were more challenging as they would alter their current lifestyles, but it was hypothesized that once residents became familiar with the first strategy, their quality of interaction and feelings would be further enhanced with the second and third strategies.

A follow-up case study was conducted to confirm and deepen the findings from previous work. We followed the first strategy to design 'Reading to Sharing' (R2S), an IPD system to promote residents' social interaction by digitally augmenting printed newspapers. Guided by the lessons from OutLook, co-creation methods were adopted to more involve residents in the design process where the design factors were continuously identified and verified. Two phases of co-design sessions were conducted with thirteen residents in a nursing home. The findings showed that most residents had positive perceptions of an envisioned system that could attract them to use and create more social opportunities. The chosen method and process were effective for capturing residents' requirements and thus guiding the system development. R2S was evaluated through field trials in two stages. In Stage 1, supervised field trial sessions were carried out with twenty residents in two nursing homes. It aimed to investigate the participants' interaction patterns with R2S and explore its potential social impacts. Additionally, the perceived user experience of R2S was assessed to validate the design factors and refine the system. The result showed that R2S was a success in keeping the group members engaged and mainly actively engaged in content sharing and viewing. It was found to be effective in catalyzing social interaction between the group members. Furthermore, R2S was found to be able to support various levels of social interaction. However, neither the questionnaires nor the interviews reported significant differences in their perceived closeness. In Stage 2, the upgraded version of R2S was tested in a six-week open field trial to further investigate the participants' user experience, their interaction with R2S, and its social impact on their daily lives. The result indicated that although the residents' reactions varied with conditions, R2S has been shown to have a positive impact on residents' social behaviors. Furthermore, it was encouraging to find that R2S was able to motivate some residents to change their long-term social habits and group compositions. The participants'

perceived user experience of R2S was very positive, which proved that such systems, if appropriately designed and introduced, could be used by residents independently, freely, and pleasantly in public spaces. Finally, key design implications and social roles of IPDs in nursing homes were summarized. The user types and interaction with tabletop IPD systems in nursing homes were conceptualized.

In conclusion, the findings of our research showed that IPD systems, with proper design and deployment, are able to be applied as a new form of intervention to enhance nursing home residents' social interaction. Although the social impact of IPDs might not be as significant as organized social activities, it can provide an open platform in public care environments to continuously facilitate residents' social interaction and meaningful activities throughout the day. The knowledge generated from this PhD research includes a framework of key design factors, interaction patterns, conceptualized user types and interaction phases, and a model of design process, which could not only contribute to design and the HCI community but also provoke a deeper understanding on other disciplines such as geriatric nursing.

莫道桑榆晚，为霞尚满天。

Late as it is, the setting sun can still make a skyful of roseate clouds.

– 刘禹锡 *by Yuxi Liu (AD 836)*

CONTENTS

为学须先立志

One should make his determination before doing any research

-《朱子语类》<ZhuZiYuLei> [AD 1270]

Chapter 1. Introduction

1.1. Nursing Home and its Social Issues

Global population ageing has led to increasing demand for high quality specialized facilities and institutional care (McClannahan and Risley, 1975). In the past decades, the number of facilities devoted to the care of frail older adults maintains a steady growth across the world (Hajjar, 2013). These are often referred to as nursing homes. However, regarding the definition of the term "nursing home" and the types of care provided in a nursing home, there is much ambiguity in the international literature (Sanford et al., 2015).

In this thesis, the definition of the term "nursing home" is based on a survey conducted by IAGG (International Association of Gerontology and Geriatrics) and AMDA (The Society for Post-Acute and Long-Term Care Medicine) foundation to achieve an international consensus. The resulting definition was concluded as follows: "*A nursing home is a facility with a domestic-styled environment that provides 24-hour functional support and care for persons who require assistance with assisted daily livings (ADLs) and who often have complex health needs and increased vulnerability. Residency within a nursing home may be relatively brief for respite purposes, short term (rehabilitative), or long term, and may also provide palliative/hospice and end-of-life care.*" (Sanford et al., 2015, page 183) The built environment of nursing homes is specified by van Hoof et al. (2016), which included not only the private space, personal belongings, but also the (quasi-) public space, technology, the look and feel, and the outdoors and location.

Although there are differences between the elderly-care policies of different countries, most older adults are admitted to nursing homes because they can no longer reside in their homes independently or the home care services fail to meet their needs (Gillsjö et al., 2011; Schols et al., 2004). Thus, nursing home residents are characterized as a frail group with numerous chronic,

comorbid conditions and multiple functional deficits (Mulrow et al., 1994). Besides, it was reported that more than half of the nursing home residents suffer from cognitive, behavioral, and emotional impairments (Rovner et al., 1986). The physical and mental degradations make them vulnerable to their surroundings, and they have to rely on caregivers and visiting family members to provide not only physical care but also psychological and social care (Ice, 2002). However, their demands, especially social needs, are difficult to be satisfied due to decreasing contact with their family and limited care resources.

Apart from the relationships with staff and family members, positive and meaningful peer relationships between residents can also contribute to "a good life" in care settings. But the lack of social interaction between residents is found to be a prevalent problem in nursing homes. The impoverished social ecology in public care environments can diminish residents' mutual interaction and the provision of adequate therapeutic care (Carstensen and Erickson, 1986). Thirty years ago, nursing homes were initially built based on a medical–somatic model of care, focusing on chronic physical diseases and progressive dementia. The official aim of caregiving was primarily to keep residents safe and healthy (Foldes, 1990). Therefore, nursing homes were frequently considered as places where residents suffer from social isolation and loneliness (Drageset, 2004). Erving Goffman (1961) noted the likeness between prisons and nursing homes, and described these settings as "total institutions", along with military training camps, orphanages, and mental hospitals. Nursing home residents have to wait for care, follow the rules and live by institutional schedules, which could easily lead to inactive lifestyles. In the 1970s, Gottesman and Bourestom (1974) observed the daily activities of 1,144 residents in 40 nursing homes. They reported that more than half of the residents' time was spent doing nothing, which suggests more focus on social care. Twenty-five years later, with the development of care facilities, activities and therapeutic recreation prompted by government and professionals, Ice (2002) reexamined the daily lives of 27 residents in a nursing home and found that such a passive lifestyle was still prevalent. It was reported that residents spent the majority of their time in their rooms, sitting and alone (Ice, 2002). The result identified the needs to keep developing programmed activities to promote residents' social activities. Furthermore, the care facilities and environment need to be more engaging to

promote residents' social interaction and support their meaningful activities throughout the day. In recent years, an increasing number of nursing homes are established based on patient-centered models with more attention to residents' autonomy and overall well-being (Eijkelenboom et al 2017). With the effort in architectural and space design of care environments, many nursing homes explored to not only provide private rooms that resemble home but also create comfortable public environments to enhance residents' social wellbeing. However, according to a more recent observation study on the daily activities of 723 home residents in seven nursing homes (Ouden et al., 2015), residents were still largely observed in their rooms inactively. Ouden et al (2015) revealed the lack of attractive and engaging public facilities in conventional care environments. She advocated that more efforts should be taken to encourage residents to walk out from their private rooms.

1.2. Social Intervention in Nursing Homes and its Limitations

In addition to improving the built environment, hosting various scheduled activities has long been recognized as a conventional and mainstream solution to attract residents to go to public spaces and engage in social activities (Heath and Phair, 2000). Such activities, sometimes also referred to as therapeutic programs, are usually organized in the forms of music activities, lectures, creative workshops, performances, games, current or historical events, pet activities and exercise classes. Significant variation was found between depressed and non-depressed residents in their frequency of attending organized activities (Voelkl and M.A. Mathieu, 1993). Close relationships were also identified between sensory impairments of nursing home residents and their time spent in activities (Resnick et al., 1997). However, although the benefits of the activities have been repeatedly confirmed in numerous studies and many residents claim to enjoy the activities, such organized social interventions have limitations:

Firstly, it calls for strong human resource, material and financial support. Secondly, such activities are held in the public spaces within nursing homes only on an intermittent basis, which lacks continuous influence on residents' social feelings and behaviors. From the perspective of individual residents,

they have to find things to do when there is no activity, which can easily lead to an inactive lifestyle. However, even if the activities could be held continuously throughout the day, the residents would feel intrusive if these activities keep occupying their public areas. Thirdly, since the nursing home is an institutional space where people from different backgrounds live together, activities based on certain themes are difficult to meet the variety of needs. Last but not least, activities are usually led by caregivers and passively followed by residents. Researchers in this field argue that residents also need the freedom to choose whether to be social or not at a certain moment in order to maintain a sense of individual control. Chown (1981) claimed that the provision of social opportunities is more beneficial to residents than enforced sociability. Therefore, a more innovative approach is needed to enhance the nursing environment settings to facilitate the elderly to have meaningful activities and social interactions.

1.3. Interactive Public Display (IPD) and its Social Impacts

Based on my experience and knowledge on designing and developing display technologies in public spaces (Kang et al., 2013; Frens et al., 2013; Zhang et al., 2013), I was motivated to explore the potential to design and deploy interactive public displays to enhance the attractiveness and sociability of nursing environments.

With the rapid development of display technology and the increasing popularity of multimedia information, we have witnessed a proliferation of digital displays in our daily lives. The digital content can not only be shown in personal devices but is also permeating public spaces for advertisement, entertainment and exhibition, increasingly enhancing and replacing traditional physical signs (Müller et al., 2010). A large situated screen has been a common form of public displays since the early years. It was applied as a broadcasting system to present digital texts, photos and videos not only in open public spaces such as city plazas and architectural facades, but also in various semi-public spaces such as museums, supermarkets, libraries and offices. However, the impact of such one-way broadcasting on viewers is very limited. Müller, et al. (2009) found the effect called "display blindness", which means passers-

by tend to ignore displays because usually they don't have expectations of interesting content.

With the maturity of sensor technology, social networking and information technology, public displays nowadays are becoming increasingly interactive to attract the attention of passers-by, which could largely reduce the blindness effect. Furthermore, the public nature of such interactive platforms could have a major impact on society by creating more engaging environments. In recent years, we have witnessed the success of many interactive public displays to stimulate the social interaction among the strangers in the same space (Prante et al., 2003; Wouters et al., 2016; Beyer et al., 2014). People nearby can be socially connected by interacting with the displays, consciously or unconsciously (Vogel and Balakrishnan, 2004). In these cases, the forms of display are extending from screen to projection, lighting, and mechanical installations (Funk et al., 2013; Jafarinaimi et al., 2005; Monastero and McGookin, 2018; Müller et al., 2012; Rogers et al., 2010).

Interactive public displays are also increasingly applied in communities. They can be designed to facilitate group tasks such as schedule making, memory recording and collaborative working within organizations (Churchill, 2004). People from the same community can post their information to the public display when they pass by or remotely by individual devices (Hindmarsh et al., 2005). Such a social network can not only offer awareness of peers' activities, but also enhance a sense of belonging (Kang et al., 2013). In addition, multiple displays can be installed in different areas within the community to overcome the spatial and social barriers between group members (Prante et al., 2003).

1.4. Research Opportunities and Challenges

Given the common social problems in nursing homes and the limitations of conventional social interventions, we uncovered the opportunities to design and deploy interactive public displays (IPDs) to make the public care environment more attractive and engaging for residents. Firstly, as the price of display and computing hardware devices continues to drop, IPDs are becoming increasingly accessible to general institutions and individuals and

have the potential to be deployed on large scales. Besides, with the maturity of interface design and technologies, it takes increasingly less effort for the display administrators to set up and maintain IPDs in long-term use. Secondly, enabled by ubiquitous computing and sensory technologies, IPDs can continuously detect the behavior of people nearby and provide real-time feedback to support multi-user interactions simultaneously. Thirdly, under the influence of booming multimedia applications and social networks, IPD viewers are provided with a wealth of digital information to meet their various interests. Furthermore, we expect that IPDs can offer an open platform that can be freely accessed by nursing home residents whenever they have social needs rather than waiting for family members, caregivers or scheduled programs, thus becoming an active form of social intervention.

These opportunities also bring multiple challenges to researchers and designers in this field. Although there have been plenty of explorations to design such systems as a means of promoting information sharing, encouraging social participation and strengthening weak social ties, most IPD applications on the market or in prior studies are developed for the younger generation. Since older adults have long been playing a minor role in research and design on novel technologies, few of the current applications can be directly applied in nursing homes due to the specificity of the context and target group. Therefore, the lack of considerations on nursing home residents' design requirements and social needs can lead to low user acceptance. Few implications could be found from current literature and practices on the key design factors that would determine the success of IPDs in nursing homes for residents' social interaction and wellbeing. Additionally, due to the digital divide and lack of mutual understanding, designing social technologies for frail older people could be challenging. In order to design appropriate socio-technical systems for nursing home residents, there is an increasing need to explore effective design processes and methods to collect user needs and feedback. In terms of evaluation, there has long been a conflict between the intrusiveness of evaluation methods and the intention to keep the public display at the periphery of the user's attention. Messeter and Molenaar's (2012) research uncovered the lack of research discussing how to evaluate general interactive public displays in real-world settings. To the best of our knowledge, none of the earlier studies specially presented how to evaluate IPDs in nursing homes for social interaction, and little is

known about residents' reactions and the social impact of IPDs in their daily lives. Furthermore, even though there have been several attempts to observe residents' daily activities (Gottesman and Bourestom, 1974; Ice, 2002; Ouden et al., 2015), they only provided overall descriptions about residents' lives. The current understanding of residents' behaviors (especially social interaction) in public care environments was still very superficial, which is difficult to guide future design and development of IPDs in nursing homes.

1.5. Research Questions

To verify the uncovered opportunities, we explored to investigate the effectiveness of IPDs on nursing home residents' social interaction. The IPDs should not only be acceptable and attractive for residents, but also positively influence residents' social interaction. Our fundamental research objective is to provide implications to inform future works in the design and deployment of IPDs in nursing homes for residents' social interaction. For consistency, we only studied the Dutch situation in this dissertation. But the previous studies mentioned above indicated that the nursing homes in different countries faced similar social problems and IPDs was effective to trigger social interaction in diverse contexts. We believe that the implications derived from this research can be applied in many other situations.

In this thesis, a series of studies were conducted with an overall research question: *How to design IPDs in nursing homes to promote social interaction among residents?* This question can be answered via addressing the challenges mentioned above from the perspectives of design factors, user interaction, social impact and design methods, thus dividing it into four research questions, which are:

RQ1: *Which factors should be considered when designing and deploying IPDs to promote social interaction among nursing home residents?*

Numerous prior studies have found that the attractiveness, engagement and social impact of IPD systems are complex. They depend on many factors such as the position and the orientation of the display, the content type,

the content format and dynamics, and the social context (Parra et al., 2014; Huang et al., 2008; Akpan et al., 2013). Our research aims to identify the important factors of IPDs for nursing homes residents' social interaction and provide practical guidance for future design and deployment in this domain.

RQ2: *To what extent can nursing home residents accept and engage with IPDs?*

In the academic and engineering community, there seems to be a stereotypical view that older adults' acceptance of modern technologies is inadequate (Hawthorn, 2007). In order to influence nursing home residents' social activities, it is important to understand residents' attitudes and acceptance towards IPDs deployed in their living environment and find out related factors. Additionally, there are plenty of evidence indicating that older adults have more difficulties in using novel technologies than younger people, which might lead to a lower degree of proficiency, utilization and user experience (Dickinson et al., 2007). Therefore, our research was also motivated to explore residents' adoption of IPDs, the degrees of engagement, and their perceived user experience.

RQ3: *To what extent can IPDs influence nursing home residents' social lives?*

As mentioned above, numerous studies have indicated the effectiveness of IPDs in nurturing social interaction and bonding for community members (Grasso, et al, 2003). However, researchers also found that many nursing home residents kept a stable but inactive lifestyle, and they were vulnerable to surrounding changes. One of the core objectives of our research is to investigate the social impact of IPDs in care environments. We are interested in whether IPD systems can influence residents' habits, and if they can, we aim to explore further the roles that IPDs play in residents' social lives.

RQ4: *How to involve nursing home residents to contribute to the design of IPDs for their social interaction?*

The challenges of designing socio-technical systems for older adults have been widely acknowledged by considerable studies. Numerous problems

were reported in the process of extracting design requirements and collecting evaluation data (Newell et al., 2007). By reflecting our practice throughout this thesis, our research also looks at the design procedures, methods and techniques to involve nursing home residents to contribute to derived design factors.

1.6. Research Approach

The overall approach adopted in this thesis is research-through- design (RtD). The specificity of our research context and target group requires us to conduct structured studies via specific design cases. Through an iterative process of developing and evaluating experimental IPD systems in nursing homes, knowledge can be generated to answer the stated questions and also inform future design in consequent cycles.

Research-through-design is originated from Frayling's (1993) paper, first known as the term "research through design and art". Over the years, Forlizzi and Zimmerman kept expanding and formalizing RtD as a research approach through extensive literature reviews and interviews with experts (Zimmerman et al., 2010). According to their studies, RtD was briefly described as a process of "*iteratively designing artifacts as a creative way of investigating what a potential future might be.*" (Zimmerman et al., 2013, page 311) The interviews repeatedly confirmed the academic contributions of RtD to a larger research community, indicating that knowledge and theory can be produced via RtD to inform different types of design and influence the research in other disciplines.

Besides its popularity and validity, we used this approach mainly because of the complexity of the problem that we attempt to deal with. As mentioned above, social problems in nursing homes have long been a societal problem caused by multiple factors, including global aging, the development of healthcare facilities, cultural attitudes toward aging, care services and policies, etc. Rittel and Webber (1973) referred to such problems as "wicked problems" that are inherently different from the "tame" problems that scientists and engineers often deal with, and they cannot be accurately modeled and solved using scientific or engineering modes of inquiry (Zimmerman et al., 2010).

Furthermore, Rittel and Webber (1973) indicated that the solutions to wicked problems are often not assessed by conventionalized criteria of true or false, but more likely to be expressed as "better or worse" or "good enough." Under the continuous influences of various factors, significant differences are difficult to be observed only by manipulating certain variables of artifacts to be designed. Therefore, the uniqueness of the problem and the limited room for rigorous experimentation further lead to our adoption of RtD as an overall approach. It provides us with a design inquiry to holistically integrate various design factors through the development of desired artifacts to transform the problematic situation to a "better" state. Moreover, its iterative approach allows us to continuously extract the design implications and knowledge across different disciplines from the analysis of designed artifacts and their impact on the situation and wicked problem it have.

Although RtD has been widely recognized and extensively used by HCI and design researchers, there is a large variety in regard to their specific processes, activities and methods. No consensus has been reached upon how RtD should be conducted. Although Forlizzi and Zimmerman (2010) called for the development of agreed methodological standards with a firm theoretical foundation, Gaver (2012) argued that such variation should not be seen as a lack of "cumulative progress" but is natural for a "generative endeavor". He further suggested that design researchers should view design theories as annotations of design outcomes rather than developing increasingly comprehensive standards.

Our research presented in this thesis followed Gaver's (2012) opinion and used RtD as a guiding ideology rather than a fixed methodology. The activities, methods and processes in our research was inspired by previous studies in the field and developed according to our specific context, users and research objectives. Generally, our research in this thesis can be described as a process that moves from a single design instance (Chapter 3) towards a more complex series of investigation, design and validations (Chapter 4 and 5). Due to the lack of reference, we used RtD in the case "OutLook" (Chapter 3) as an exploration to identify important factors and serendipitously discover what is unexpected but valuable (Keller 2005). The prototype mainly served as a filter to screen out unnecessary elements and allowed us to focus on particular regions in the following phases so that knowledge could be

extracted more precisely and effectively (Wensveen & Matthews, 2014). In the case of OutLook, RtD was also used to form the research basis of the whole study by providing understanding of the care environments and nursing home residents beyond literature. Guided by the knowledge from Chapter 3, RtD continued to be used with the aspiration to bring the situation to a preferred state via the follow-up design case "Reading-to Sharing" (R2S). The research findings in the explorative case were aimed to be repeatedly confirmed, refined or challenged in a more complex iteration of design and evaluation in the following case. Design implications were derived in the process of pursuing a better version of the prototype system. We also aimed to evaluate the design methods by collecting the reflections on the design activities organized throughout the research. Furthermore, through the user trials, we aimed to conceptualize our findings about the interaction between nursing home residents and IPDs and its impact on residents' social lives, which can not only contribute to the HCI community but also provoke a deeper understanding of other disciplines such as geriatric nursing.

1.7. Thesis Outline

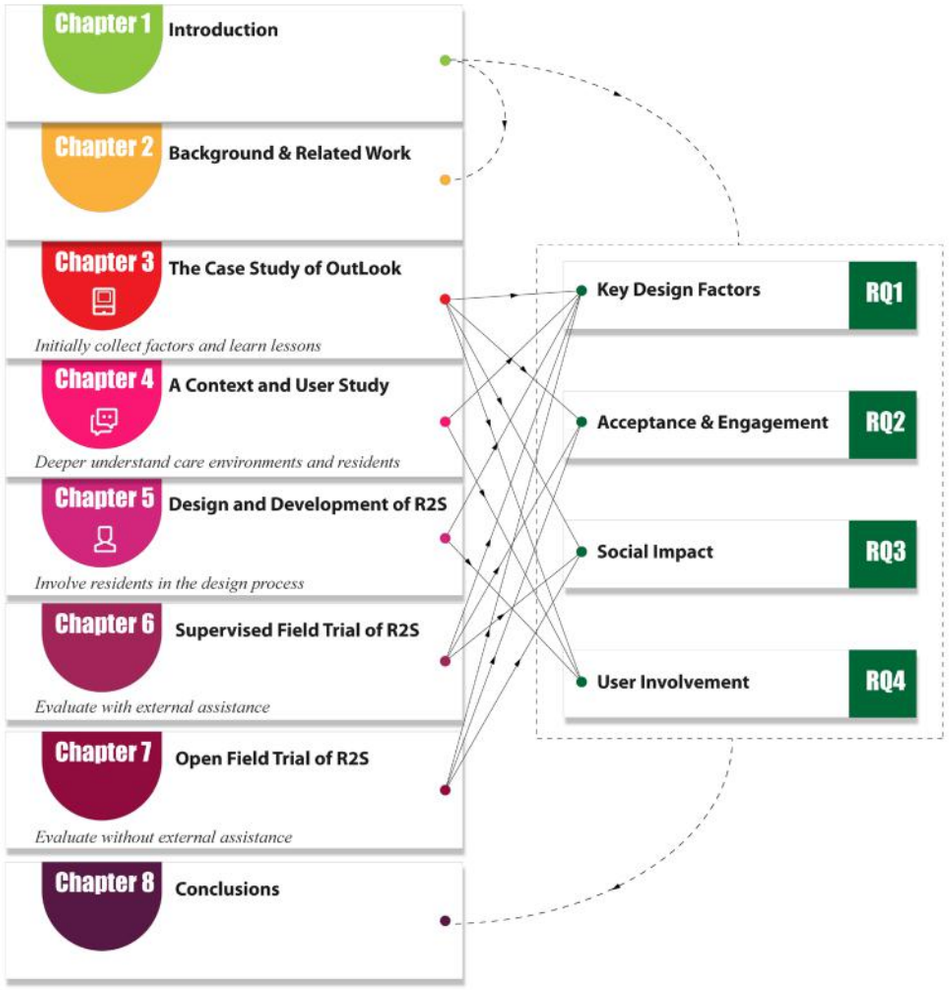


Figure 1-1 The thesis outline

Figure 1-1 provides an overview of the structure of this thesis. As shown in the figure, the introduction is followed by seven chapters in this thesis:

Chapter 2 provides the contextual and theoretical foundation of our research in this thesis. We firstly elaborate on the contextual background under which our research is conducted. Then the state of the art in the field of social-

technical interventions in care settings is introduced. We also provide a brief review of the existing research related to the four research questions.

Chapter 3 presents an explorative case study called 'OutLook'. It is carried out with two other PhD candidates (Xu Lin and Cun Li) and serves as a research basis for my following studies. The results confirm the social potential of IPDs in care environments. Key design factors are initially identified, and lessons learned are summarized from this case study.

Chapter 4 presents a context and user study. It is driven by the insights from the case study of 'OutLook' to deeper understand care environments and residents. The main objective is to investigate residents' media habits, their preferred genres, social demands and barriers. Based on the results, three design strategies are proposed.

Chapter 5 presents the design and development of an IPD system called Reading to Sharing (R2S). The design of R2S is inspired by the first design strategy of augmenting residents' experience of existing media habits. Guided by the lessons from OutLook, two phases of co-creation sessions are performed to involve residents more in the design process where the design factors are continuously verified and identified. Reflections of the methods adopted are also summarized.

Chapter 6 describes the supervised field trial of R2S. Residents are invited to experience R2S in groups with the assistance of researchers or caregivers. It is carried out mainly to investigate the participants' engagement levels with R2S and explore its potential social impacts. Additionally, the perceived user experience of R2S is assessed to validate the design factors and refine the system.

Chapter 7 presents the open field trial of the upgraded version of R2S. It is deployed in a public care environment for residents to use without any external assistance. The objectives are to investigate further the participants' user experience, their interaction with R2S and its social impact on their daily lives. The results guide us to conceptualize typical user types, and their behaviors around tabletop IPDs in nursing homes. We also summarize the social roles of tabletop IPDs in residents' everyday life and the implications

for design and deployment.

Finally, in Chapter 8, the research findings and results are concluded by addressing each of the four research questions. The limitations of this thesis, future research and design directions are also discussed.

博观而约取

Read widely and absorb the best from what you read

– 苏轼 *Su Shi （AD 1076）*

Chapter 2.
Background and Related Work

2.1 Introduction

In Chapter 1, we have explained our research motivations, objectives, and the thesis outline. This chapter is intended to introduce the contextual background where we conducted our research and formulate the scope of this thesis. To begin with, we specify that the research presented in this thesis is carried out in contemporary Dutch society, then we briefly describe the situation of aging, the nursing industry, and related policies in the Netherland (Section 2.1). The contextual background is followed by a summary of early explorations and state-of-the-art design practices of socio-technical interventions in care settings (Section 2.2). Then, we briefly provide a literature review according to the research questions presented in Chapter 1. In Section 2.3, we identify five design factors of interactive public displays (IPDs) that have been specially mentioned in many previous studies (RQ1). To investigate the interaction between nursing home residents and IPDs (RQ2), we introduce five typical interaction models conceptualized by previous researchers (Section 2.4). To explore the social aspects of IPDs (RQ3), we firstly introduce Goffman's dramaturgical theory as a foundation for later studies on the social effects of IPDs (Section 2.5.1). In Section 2.5.2 and 2.5.3, we outline the prior work that investigated users' social experience and interaction around IPDs. The design strategies derived from these studies are further explained. Section 2.6 contains a discussion of the necessity and feasibility to involve older people in developing new technologies (RQ4). Typical methods of involvement and techniques adopted in previous case studies are also described. For the sake of readability, we present all the related work in one chapter before the field studies. However, in practice, they were gradually collected and learned throughout my PhD research. Therefore, some of the theories and studies didn't directly guide all our field studies. They were found afterwards as important knowledge to inform our following studies and future research in this field.

2.2 Contextual Background

The research presented in this thesis was conducted in the specific context of contemporary Dutch society. In 2018, the share of over-65s in Dutch population was reported to be 19.5%. Because of demographic developments, the proportion is expected to quickly rise to 25.2% and the share of over-80s is expected to double to 8.5% by 2040 (European Nursing Homes Report, 2019). The aging population directly influences the development of Dutch nursing homes.

According to a report in 2003 (Schols et al., 2004), there were about 330 nursing homes in the Netherlands with more than 58,000 beds. Generally, there are three kinds of nursing homes in the Netherlands. About 13 % only have somatic wards, 14 % only have psychogeriatric wards, and the majority (73%) of the nursing homes have both of them (Schols et al., 2004). In 2016, it was reported that approximately 65,000 people were living in Dutch nursing homes (van Hoof et al., 2016). A more recent data provided by the National Institute for Public Health and the Environment (RIVM) indicated that the number has grown to 125,000. The equipment rate (number of beds/population-over-80) in the Netherlands is registered at about 14.5%, and it is expected that around 35,000 extra beds will be needed by 2030 (European Nursing Homes Report 2019).

The rising demands present numerous challenges to the Dutch government. Traditionally, long-term care facilities are managed by non-profit operators, and nursing homes are funded by long-term care insurance. In the coming decades, as the health care costs and expenditure rise sharply, nursing homes are expected to be operated within a fixed budget. Therefore, despite the increasing demand for beds, most operators are reluctant to develop new properties (Schols et al., 2004). To meet the needs, the government has been promoting the privatization of the Dutch market for elderly care (Dixon, 2006). Since 2015, there have been a rising number of for-profit operators with private nursing homes. However, the market share of private sectors is relatively small currently.

As a result, although the government is keen to provide sufficient care facilities, it advocates older people to live at home for as long as possible

if they can continue living independently with help from the municipality. People who want to move to nursing homes need to be assessed to prove that they are vulnerable elderly or people with disabilities. Additionally, since an investigation conducted by Health Care Inspectorate (IGZ) showed that the knowledge, skills and availability of caregivers could not meet the care needs of residents, the government has launched a series of actions to improve the quality of nursing home care such as offering professional training and improving supervision. Furthermore, the Ministry of Health, Welfare and Sport encourages the development of new technologies to reduce the workload of caregivers. The European Ambient Assisted Living (AAL) joint program has been funded to improve older people's quality of life and independence by ICT applications.

2.3 Socio-technical Interventions in Care Settings

The disengagement theory of aging pointed out that growing old is an inevitable process of gradually withdrawing from the world at a physical, psychological, and social level (Cumming and Henry, 1961). The rapid development of technologies has been criticized for accelerating this process and aggravating social isolation because numerous reports have indicated that when younger generations live in a digital world, older adults are left behind due to the lack of confidence, interest, and social capital to support them to use new technologies (Paul and Stegbauer, 2005). However, there are more studies showing that technologies with proper design can be used to reduce social isolation among seniors.

In the past decades, a growing body of interdisciplinary research has been focusing on what kind of technologies and how the technologies can support older people's social activities in the wake of physical, cognitive, and mobility challenges. Baez et al. (2019) identified two research and design trends in this field by borrowing the classification from computer-mediated communication research (Tong & Walther, 2011): ***technology for virtual participation*** (i.e., communication over a distance) and ***technology for co-located participation*** (i.e., face-to-face). Based on this classification, we further reviewed the prior work in the context of aged-care settings, as described in the following two sections:

2.3.1 Technology for Interaction over a Distance

Since nursing home residents' opportunities to travel to participate in social activities are often restricted by managing policies and their physical degradations, the prevalence of loneliness among older people in nursing homes is significantly more than that of community-dwelling populations (Victor, 2012). Therefore, various kinds of technologies for virtual interaction have been developed to overcome geographical and physical barriers. Such technologies were mainly applied in residents' private rooms.

One typical form was ICT applications that enable residents to directly communicate with their family or close friends living at a distance (Vutborg et al., 2010). The effects of such applications depended highly on the availability of residents' stable social partners, which might also explain the nonsignificant changes or even negative impacts reported in some studies (Woodward et al., 2011).

Another direction was to promote residents' online interaction via social network technologies. Various platforms were developed to encourage them to participate in online groups, communities and activities without leaving their rooms (Hutto & Bell, 2014; Báez et al., 2016). Since the majority of such systems need to be actively used by residents, the social effects might be restricted by their acceptance and capability of using new technologies. Given this, smart home technology and Ambient Intelligence (AmI) was found to be a promising way because they do not require residents to interact with the system proactively. In the so-called 'connected home' or 'ubiquitous home', ambient technologies can discreetly blend into the home environment and unobtrusively gather or provide residents' social information. A common form in this domain was ambient display or lighting system that continuously provided social awareness of residents' family, friends or caregivers (Dadlani et al., 2010; Davis et al., 2017; Biemans & Dijk, 2009).

2.3.2 Technology for Co-located Interaction

Despite the great efforts to support nursing home residents' virtual interaction, face-to-face interaction was found to be more powerful in guarding against depression in later years than other forms of socialization (Teo et al., 2015). Furthermore, Yuan et al. (2016) found older people preferred in-person communication but they often could not get adequate face-to-face interactions as they desired.

In recent years, there is a growing area of design and research focusing on how technology can support co-located interaction in nursing homes. Such interaction mainly took place among residents or between residents and their caregivers. We further divided the related research into two sub-categories based on different social situations. One branch aimed to facilitate organized social programs, and the other one targeted to support unplanned social activities.

- *For organized social program*

There has been particular attention in research on the role of technologies in organized social programs in nursing homes. As a common and basic form of technology, traditional devices (e.g., televisions, laptops, tablets) have been widely used in organized social programs (Stevenson et al., 2000). However, most of them merely served as caregivers' tools to play media content. Given this, there is a growing interest in designing more engaging socio-technical applications for organized programs. New technologies are increasingly applied as alternative tools to enhance residents' engagement in organized programs. Lin et al. (2018) conducted a field study and found that the residents who experienced Virtual Reality (VR) content (e.g., 360 videos, Google Street View, and guided tours) reported being less socially isolated. Interactive tables and virtual environments have also been proved to be effective in such programs, but the majority of them were designed for residents with dementia (Astell et al., 2010; Feng et al., 2017; Good et al., 2019; Descheneaux & Pigot, 2009). Additionally, some studies have indicated that exergames (games with remote control and motion sensors) could be used to promote residents' physical activities and stimulate social interaction (Báez et al., 2016; Gerling et al., 2010), but such intervention has relatively high requirements on residents' senses and motor skills.

- *For unplanned social activity*

Although numerous studies have proved the effectiveness of technologies in organized social programs (Lin et al., 2018; Báez et al., 2016; Gerling et al., 2010), such activities only constitute just a small part of residents' everyday activities (Mondaca et al., 2018). Studies have indicated that residents spent time more informally with activities that were unplanned and typically resident-initiated (Roberts & Bowers, 2015). However, to the best of our knowledge so far, the role of technologies in unplanned, and unprompted activities were much less often addressed.

One prevalent research direction in this category focuses on developing socially assistive robots. One typical example is "Paro" (Šabanović et al., 2013), which was considered as one of the landmarks in this field. It was a robot resembling a baby seal to provide companionship and generate social interaction among the residents of eldercare institutions. Paro was programmed to react to certain stimuli such as touch and light, and it was also able to recognize the keywords frequently called by users. Paro was initially evaluated in sensory group therapies for the residents with dementia, and it was found to be effective in encouraging social interaction among the participants. However, the assistance of therapists was necessary for successful human-robot interactions (Chang et al., 2013; Šabanović et al., 2013). To investigate the impact of Paro in less constrained situations, Chang et al. (2014; 2015) conducted a 13-week field study by putting Paro on the public table in a nursing home. The result was surprisingly different from previous studies in therapies. Chang et al. (2014) found that most residents ignored Paro in their daily living, and even fewer had consistent interaction with the robot. Furthermore, one-to-one interaction between residents was rarely stimulated, and most social interaction occurred with the involvement of other residents, caregivers or family. This study revealed that many residents were still reserved about using assistive social robots without external assistance in open public contexts, and the social functions of such robotic interventions need to be further explored.

Although scarcer, another direction was utilizing interactive public displays. Currently, major efforts were made on the residents with dementia. The early explorations could be traced back to the 1990s when researchers sought to

reduce demented nursing home residents' agitated behaviors by adding visual, auditory, and olfactory stimuli to simulate different types of environments inside nursing homes (Cohen & Werner, 1998). With the proliferation of modern technologies, such multi-sensory environments using Mixed Reality (MR) technologies were further explored. The public displays mainly served as a content-assist tool for animal-assistant-living therapy, reminiscence therapy and eco-therapy such as "The Virtual Forest" (Wendy et al., 2017) and "Closer to Nature" (Feng et al., 2017). Since it usually required great efforts to set up the scene, such interventions were mainly designed for repeated use in therapies rather than daily living.

The display interventions for the residents without severe cognitive impairments are very limited. Existing typical cases are "Photostroller" (Gaver et al., 2011), "Community Display" (Nazzi et al., 2015), and "OutLook (Kang et al., 2018). "Photostroller" is a mobile display designed to support residential social care by continuously displaying a slideshow of images from social media. Residents can select image categories with a removable control. "Community Display" is a big screen located in the entrance hall of a care institution. It shows residents' ongoing and planned shopping information gathered from augmented shopping trolleys. "OutLook" is an interactive gallery that can display real-time views of typical local places. It responds to residents' presence by playing a slideshow and print postcards via users' interaction. Although these studies have indicated that their display interventions are effective in promoting residents' self-motivated social interactions, the derived implications on key design factors, social impacts and design approach are still limited. Therefore, more efforts should be taken to generate more design solutions by augmenting residents' daily activities and utilizing online media resources.

2.4 Common Design Factors of IPDs (RQ1)

Designing interactive public displays (IPDs) is a complicated decision-making process to determine various system characteristics. Given the diversity of related factors, so far there are no standard classifications of all the factors related to IPDs. However, many researchers have identified some important factors when designing IPDs and categorized them from different perspectives to provide comprehensive guides for designers and developers in this domain. In this section, we briefly introduce the common design factors of IPDs that have been pointed out by previous studies.

2.4.1 Mental Models

A mental model mainly illustrates how users intuitively perceive the world around a display, which is essential for the designers to generate design concepts and determine the types of content and related functions. Müller et al. (2010) identified four prevailing mental models of designing public displays based on metaphors from the real world: (1) *posters*, (2) *windows*, (3) *mirrors*, and (4) *overlays*.

(1) IPDs following the *poster* model are widely applied as a replacement of conventional printed posters with texts and graphics. They are often attached to walls or other vertical surfaces to display adapted information created for their analog counterparts. Some digital posters are often enhanced with sensing capabilities and interactive features to attract people in the vicinity. However, due to the association with traditional advertising posters, such IPDs are often ignored by users in the public context. One typical example is CityWall (Peltonen et al., 2008).

(2) IPDs following the *window* metaphor usually present the scenes from a remote location or virtual/augmented environments. Different from the poster model, IPDs in this category can be deployed as a distributed network, connecting the users in different places. One of the earliest explorations in this field is 'Hole-in-Space' created by Galloway and Rabinowitz (1980), which was also called 'the mother of all video chats'.

(3) IPDs following the *mirror* model simulate the function of mirrors in the real world. They are usually applied to attract passers-by and encourage interactions by reflecting the scene nearby with playful digital augmentation. For example, eMir was a digital signage that showed human faces to react the facial expression of users nearby (Exeler et al., 2009).

(4) The *overlay* model is mainly followed by the IPDs using projectors to play digital content over physical surfaces. Such displays are also called frameless displays because they have no perceptible boundaries. Since they can be seamlessly embodied in the physical environments or connected to objects, they are widely adopted in ubiquitous applications. A typical example is the Interactive Cereal Boxes presented by Pinhanez and Podlaseck (2005). It can project nutritional content information on a shelf with cereal boxes. The designers found that although the frameless displays could effectively connect the information to objects, there was a risk of creating undesirable connections and invade user's personal space.

2.4.2 Display Forms

With the development of display technologies, the display forms are becoming increasingly diverse. Koppel 's (2011) research argued that different display forms could influence users' behavior. Besides the typical form of a vertical, flat and rectangular screen, he specially discussed two other types of IPDs: (1) *tabletop displays* and (2) *non-flat public displays*. (1) Tabletop displays are often deployed in working or learning environments. One of the earliest explorations was DigitalDesk presented by Wellner (1993), which was a digitally augmented environment built around an ordinary desk. Studies have shown that the tabletop form is suitable for co-located communication and more effective in facilitating collaborative social interaction than wall-based displays (Tse et al., 2007; Rogers & Lindley, 2004). (2) So far, there have been very few studies focusing on non-flat displays in public contexts. The cylindrical display is a typical form in this category. By comparing a cylindrical display with a traditional vertical flat public display, Beyer et al. (2010) found that cylindrical displays could invite users to move around the display actively. Such displays are suitable to keep people moving and support gesture-like interaction.

Apart from the shape of the display, other display properties have also been identified to influence users' reactions, such as *size*, *resolution*, *angle*, *orientation*, and *number*. Ni et al. (2006) found that large high-resolution displays were suitable for performing navigation, search and comparison tasks. Numerous studies have also shown the advantages of large displays with high resolution for collaboration and social interaction (Dudfield et al., 2001; Guimbretière et al., 2001). However, a comparison study conducted by List and Kipp (2019) indicated that large screen (69.5" large monitor) cause more fatigue than small (13.5" tablet) and medium (28" monitor) sized displays. They suggested that a medium-sized screen may be the "golden middle" for most display applications. Regarding the display angle and orientation, Ichino et al. (2013) compared tilted, horizontal and vertical flat screens in one exhibition space, and they found that the display angle could affect user cognition and subjective responses. They further explored the impact of the angle of displays on users' social behavior and found that different display angles could significantly affect the social experience, sharing of space and social arrangement (Ichino et al., 2016). Besides size and angle, numbers of displays were also identified as an important factor. Multiple-display systems allow individual users or small groups to have their own content. A typical example in this form is Multi-Tabletop display systems called SMART tables (Kharrufa et al., 2013). Shared displays can also be utilized for collective interaction, but there is a trade-off between promoting a shared experience and supporting individual control (Inkpen et al., 2005).

2.4.3 Interaction Techniques

In terms of the typical interaction techniques of IPDs, Müller et al. (2010) outlined ten interaction modalities based on current sensor technologies, which were *presence*, *body position*, *body posture*, *facial expression*, *gaze*, *speech*, *gesture*, *remote control*, *keys*, and *touch* (Figure 2-1). Based on these interaction modalities and the mental models mentioned above, Müller et al. (2010) presented a taxonomy to support the future design of public display systems.

Buerger (2011) identified two main categories: *public displays in combination with mobile devices* and *standalone public displays*. The

former type allows users to interact with displays using provided or personal mobile devices. As shown in Figure 2-1, the interaction techniques frequently adopted in this type were classified into three groups: *extended input devices*, *pointing devices*, and *integral parts of the interaction* (Buerger, 2011). Standalone public displays can usually support direct interaction without additional devices such as touch and gesture interaction.

Kurdyukova et al. (2012) refined previous classifications and categorized three kinds of interaction techniques commonly used with IPDs: *direct*, *bodily* and *mobile based* (Figure 2-1). (1) *Direct interaction* mainly occurs when users are close to displays, and they can interact with IPDs by touching or by other technologies such as NFC devices (Seewoonauth et al., 2009). For example, HelloWall is an IPD application that demonstrates information via light patterns (Prante et al., 2003). Users near the wall can get detailed information with a device called ViewPorts. Although direct interactions are considered to be natural, fast and easy, it has requirements on the attractiveness of IPDs to motivate users to move closer (Kurdyukova et al., 2012). (2) *Bodily interaction* is enabled by the use of gestures, postures or proximity. Such techniques are usually realized by camera recognition and they are effective to gain the attention of the people in the vicinity. Besides, bodily interactions are intuitive and more likely to enhance users' enjoyment and create a playful experience (Lindley et al., 2008). A typical example is Magical Mirrors that react to the gestures of passers-by (Michelis, 2009). However, previous studies found that such interaction can increase user's cognitive and physical load (Kurdyukova et al., 2009). What's more, users might feel uncomfortable when performing gestures in public spaces, watched by other bystanders (Holleis et al., 2007). (3) *Mobile-based interaction* allows users to control the displayed content with a mobile interface. Such techniques can extend the interaction area of IPDs to any distance and minimize users' physical effort, which can further support simultaneous multi-user interaction, as applied in the case of Touch Projector (Boring et al., 2011). However, many users complained that mobile-based interaction is too technical and boring, and it was not convenient to frequently switch between large displays and mobile devices (Rukzio et al., 2006).

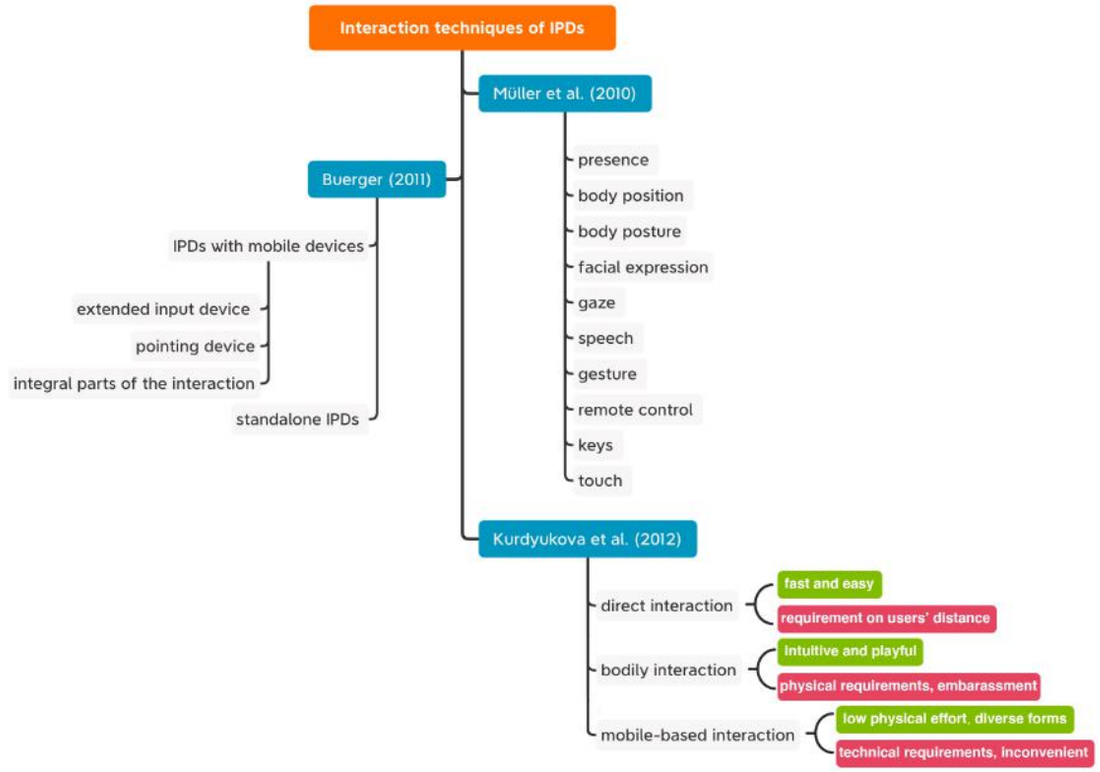


Figure 2-1 Typical interaction techniques of IPDs

As shown in Figure 2-1, by reviewing the typical interaction techniques, we find that each solution has its advantages and disadvantages for older adults. So far, however, no study has explored which specific techniques can be applied in designing IPDs that are attractive, easy, and convenient for nursing home residents, which is also what we need to investigate in our research.

2.4.4 Context

Just like many conventional interactive products or systems, previous studies on IPDs mainly focused on their intrinsic properties. However, some studies have identified the importance of the relationship between IPDs and their context.

In early studies, the context of public displays was considered to be their location or physical environment. The locations of IPDs are usually classified into two categories: (1) *public* and (2) *semi-public spaces*. Public spaces, such as airports and city squares, are the open spaces owned and controlled by the government. Semi-public spaces mainly refer to the places owned by an entity or an institution, but are usually open to public (e.g., restaurants, cafe, offices). Based on the concepts of "spatial nodes" and "links" from previous urban planning works (Hillier & Hanson, 1984), Hespanhol and Dalsgaard (2006) identified two types of spaces where IPDs could be deployed: (1) *plaza*, and (2) *thoroughfare*. In their definition, "*Plaza is a wide, open public space where a large number of citizens potentially congregate, facilitating social encounters as well as passive social practices as people watching or even loitering. A thorough-fare, by contrast, is a transit area connecting plazas, therefore characterized by the continuous flux of passers-by walking from one destination to another.*" (Hespanhol and Dalsgaard, 2006, page 4)

In recent years, people's understanding of context has been extended. Moere (2009) investigated the notion of context from two perspectives. (1) From a data-oriented view, context can be understood as the relationship between data and its representation, which is called *internal context*. According to Moere' description, such a relationship includes "the denotations - the literal meaning of the data, its quantities and patterns; connotations or suggestive meanings evoked by the design of the display, its aesthetic or persuasive qualities, and interactions with external sources of information." (Moere, 2009, page 41) (2) *The external context* mainly includes physical context, social context and informational context. Physical contexts relate to environmental settings such as light and noise conditions. Social contexts consist of cultural representations and place, time or situation of social interaction. Informational contexts involve the information and messages in the vicinity of the display. Due to the complexity of public space, IPDs are

increasingly required to adapt to changing conditions. To support the design of context-aware public systems, Kühn et al. (2011) presented a taxonomy of context features for the public domain. The taxonomy categorized three major context levels: interaction context, socio-technical context, and further context including physical, task, spatial, and temporal context, which can serve as a basis to model scenarios and interactions.

2.4.5 External Factors

The effects of IPDs "in the wild" (public areas) are often considered to be full of surprise and uncertainty, which is not only because of the dynamic context but also caused by some external factors. Since such factors do not belong to the intrinsic properties and cannot be controlled by designers, they are frequently ignored in the design process. Furthermore, they were poorly reported by previous studies because these factors were usually unrelated to their research questions.

To our knowledge, Mäkelä et al. (2017) were the first to investigate the external factors influencing IPD deployment. Through a literature review and affinity diagramming, they presented a taxonomy of external factors consisting of six categories: *weather*, *events*, *surroundings*, *space*, *inhabitants*, and *vandalism*. Four causes related to weather were found to be able to affect system performance and user experience, including sunlight, rain, temperature, and humidity. Events might occasionally lead to unexpected user behaviors because they can temporarily change the physical and social context. For example, in a case called 'Interactive Shadow Wall', the amount and duration of user interactions with the display reached to the highest level when a party was held in the space (Akpan et al., 2013). Surroundings refer to the environment around the deployment area and its persistent properties such as architectures, traffic, and people flow. Space means the exact deployment area and its physical attributes, which is different from surroundings that are outside the deployment area. Inhabitants are considered as the group of people who are not stakeholders but frequently show up in the deployment area such as cleaners, security guards, and waiters. Vandalism mainly refers to the intentional behavior that can intervene the deployment or damage the displays.

Although most of the challenges caused by these external factors cannot be controlled, Mäkelä et al. (2017) argued that researchers should look beyond these challenges and find the underlying causes. Hence, some problems might be foreseen or even avoided by adjusting correspondent factors in the design process. Mäkelä et al. (2017) summarized four types of common reactions of previous researchers including ignoring, adapting, solving, and embracing.

2.5 Interaction Models with IPDs (RQ2)

The second research question of our research focuses on the interaction between nursing home residents and IPDs in care environments. Normally, IPDs are deployed in traditional public settings where people are not aware of their presence immediately. Once users are attracted by the displays, they often experience a process of transition from subtle to deep engagement with IPDs. This phenomenon was noticed by previous researchers, and several models of interaction with IPDs have been proposed to describe this process. However, the majority of these models were developed for large situated displays in traditional public spaces, little was known about their adaptability to IPDs in public care environments. In this section, we briefly introduce the typical models, based on which our research in the following chapters aims to investigate whether these models also apply to the IPDs in care settings.

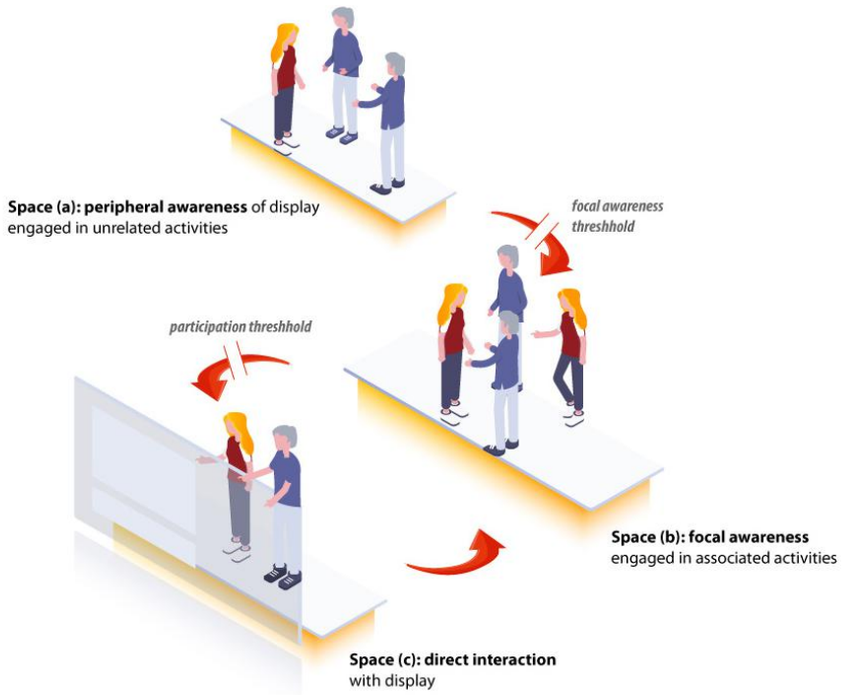


Figure 2-2 Awareness Model (Brignull & Rogers, 2003)

One of the earliest models of interaction with IPDs was presented by Brignull & Rogers (2003). Through analyzing two field studies, they identified three activity spaces around displays: (1) *Peripheral awareness* activities refer to the actions of the people who are peripherally aware of the existence of the display and barely know about it. (2) In the area of *Focal awareness* activities, people paid attention to the display and start to learn more about it via observing, gesturing or discussing. (3) *Direct interaction* means users directly engage with IPDs. As shown in Figure 2-2, this model illustrates not only the level and types of interaction around IPDs, but also the transitions between each type of interaction. Brignull & Rogers (2003) argued that IPDs should be designed to entice people to cross the threshold to focal awareness and participation. Key factors that would influence users' decision to cross the threshold are user experience, length and steps of interaction, benefits from the display, and the costs of disengagement.

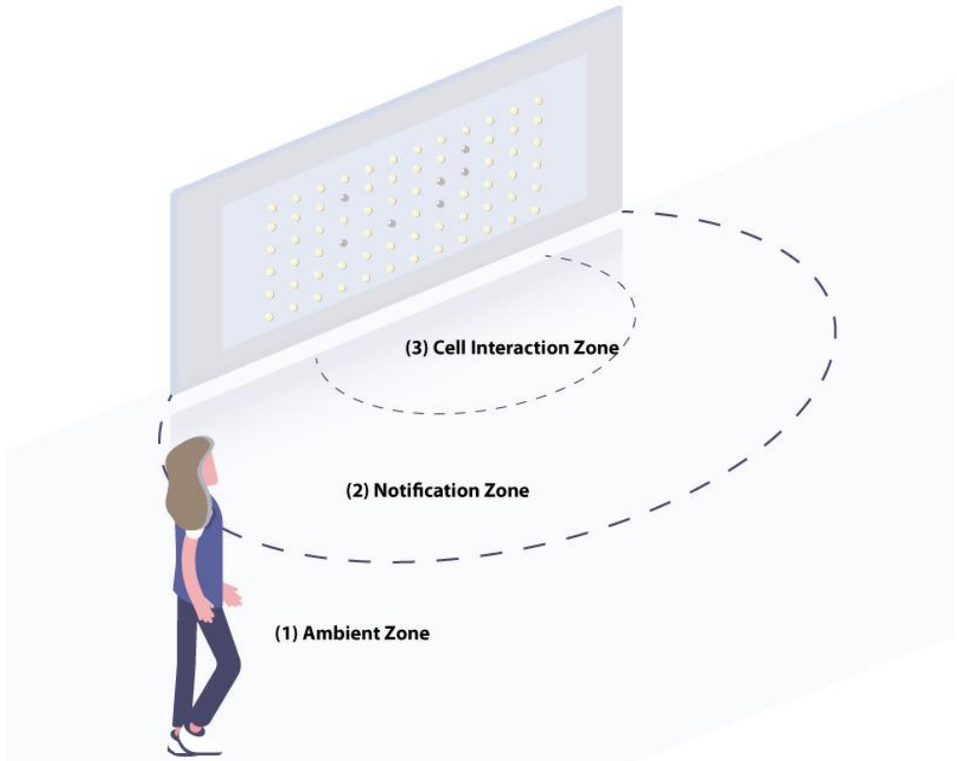


Figure 2-3 Three Zones Model (Streitz et al., 2003; Prante et al., 2003)

Streitz et al. (2003) and Prante et al. (2003) defined three zones of interaction mainly according to users' distance from wall-based IPDs (Figure 2-3). (1) The *Ambient Zone* covers the area where people are passing by beyond the range of display sensors. The display merely shows the information that is irrelevant to the presence of the people. (2) When people approach the display and trigger a reaction, they are in the *Notification Zone*. The feedback of IPDs can be directly shown to the public or sent to personal devices. (3) The *Cell Interaction Zone* refers to the area that is very close to the display, and people can interact with detailed information with their devices.

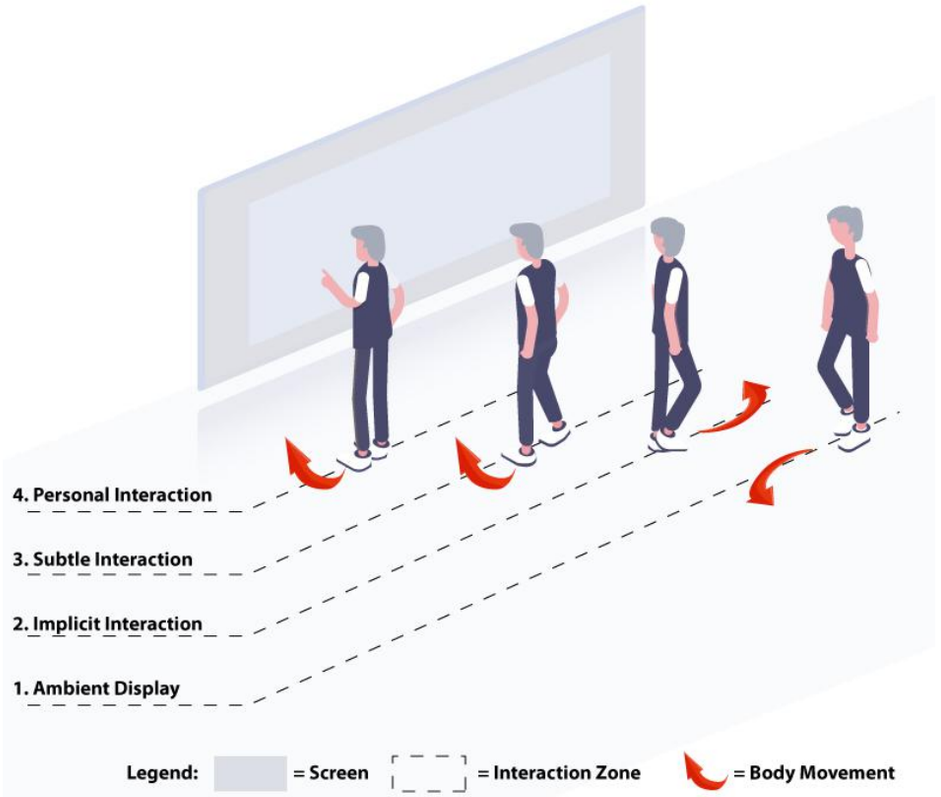


Figure 2-4 Interaction Phases Model (Vogel and Balakrishnan, 2004)

Based on the work mentioned above, Vogel and Balakrishnan (2004) proposed an alternative model that doesn't require users' distance or personal devices to distinguish each type of interaction with IPDs (Figure 2-4). Their model consists of four continuous phases with fluid transitions. (1) The *Ambient Display Phase* describes the system state where the display shows preset information. Users are the people staying in a distance or passersby who mainly interact with IPDs through quick glances. (2) The *Implicit Interaction Phase* refers to the state where peripheral reactions are provided when users pass by. In this phase, people can usually influence the display by moving their body position. (3) In the *Subtle Interaction Phase*, the user intentionally approaches and interacts with the display with subtle cues such as a pause in front of the display. They are provided with more detailed information to motivate them for deeper engagement. (4)

The *Personal Interaction Phase* mainly describes the situation where users move closer, and further interact with the display by touching for more detailed information. Vogel and Balakrishnan (2004) indicated that users should experience each type of interaction with the display through seamless transitions. Additionally, users should feel free to exit or enter each phase with minimal interference to the display.

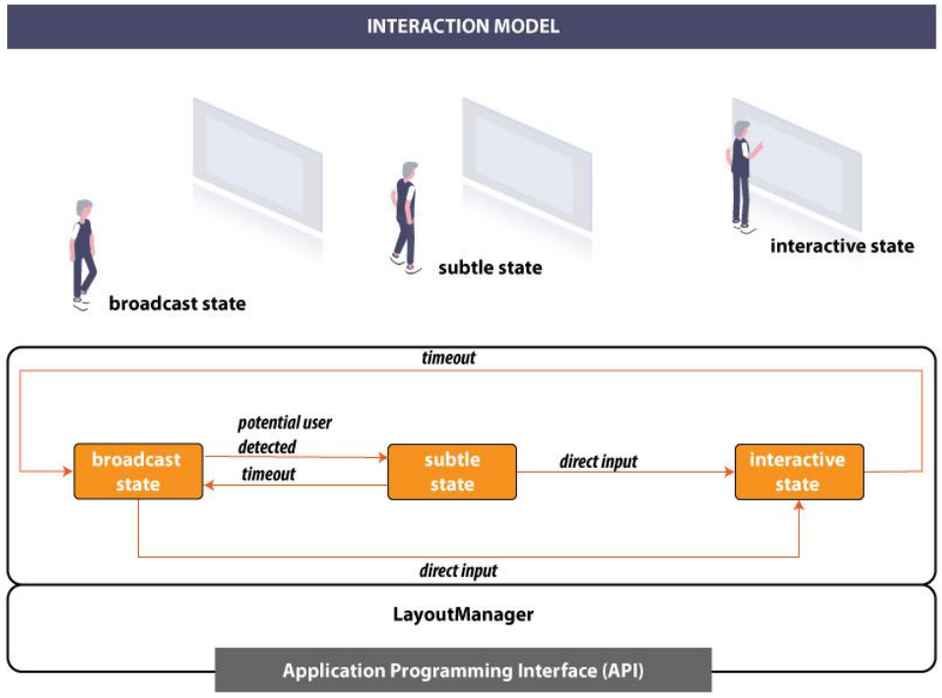


Figure 2-5 Interaction Model refined from Interaction Phases Model (Heikkinen et al., 2011)

Due to the challenges to distinguish between implicit and subtle interaction in some cases, Heikkinen et al. (2011) merged them and proposed a conceptual model with three distinct states: *broadcast*, *subtle* and *interactive* (Figure 2-5). The transition from broadcast to subtle is triggered by the detection of a user's presence, and the transitions to the interactive state are determined by users' intentional input.

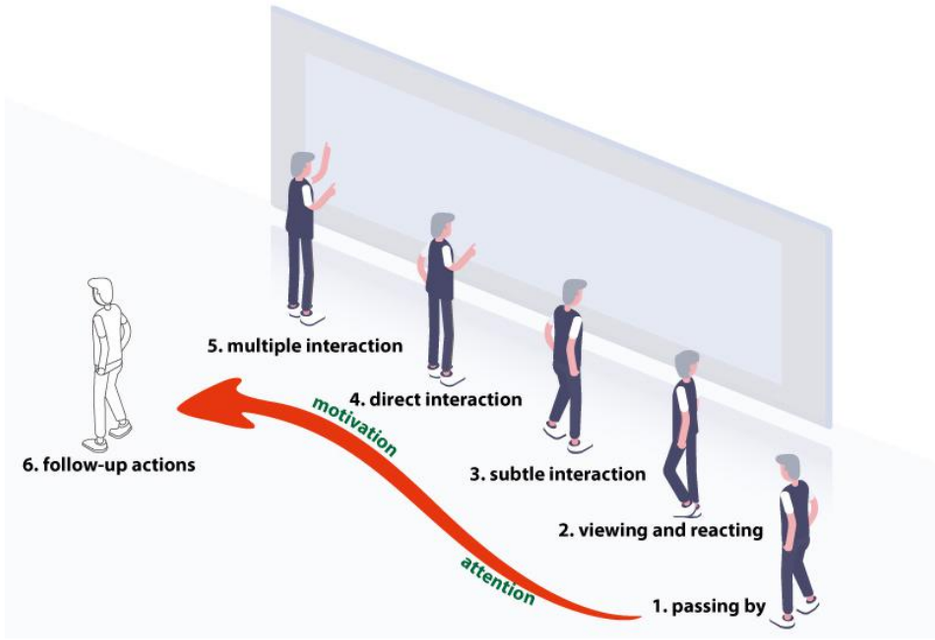


Figure 2-6 Audience Funnel Model (Michelis and Müller, 2011)

Michelis and Müller (2011) further investigated the interaction process from the case of "magic mirror" and proposed the "*audience funnel*" model. The model consisted of six phases (Figure 2-6) and was the first to illustrate the full interaction process from entering to leaving the effective coverage of IPDs. (1) In the first phase, people might be aware or unaware of the presence of the display when they are *passing by*. (2) In the second phase, people start to *pay attention* to the display and *show reactions* such as pausing and turning toward the display. (3) *Subtle interaction* occurs when the system supports distant interaction (e.g. body movement or gestures). (4) *Direct interaction* occurs when people move closer in front of the display and actively engage with it. (5) *Multiple interactions* refer to the circumstance where users explore diverse interactions, e.g., they might try different displays, interfaces or functions if they are available, or they might engage with the displays multiple times. (6) Finally, *follow-up actions* might be performed such as taking photos or leaving. Similar to previous models, Michelis & Müller (2011) pointed out the thresholds exist between phases, and designers need to find measures to overcome them such as raise the attention of passers-by, arouse the curiosities of onlookers (Figure 2-6).

2.6 Social Aspects of IPDs (RQ3)

Social interaction is a "*dynamic, changing sequence of social actions between individuals (or groups) who adapt their actions and reactions according to the actions by their interaction partner(s)*" (Chen et al., 2008, page 952-971). As mentioned in Chapter 1, social interactions are frequently observed around IPDs. Some are specially designed for, while some interactions are beyond designers' expectations. In order to enhance nursing home residents' social interaction via designing IPDs, we believe it is essential to understand the social aspects of IPDs, including the social experience and social interaction of the people in public spaces.

2.6.1 Theoretical Foundations

Besides popularizing the term "total institutions" mentioned in Chapter 1, Erving Goffman was also credited with describing everyday social interaction, which profoundly influenced later research on users' behavior in public spaces.
In his book "The Presentation of Self in Everyday Life" (1959), Goffman pointed out that people try to control the impression that they make on others in daily interactions. Role performance was found to be an important way to manage self-impression on others, which led Goffman to develop the "dramaturgical theory". The key contribution of this theory is a new perspective to view human interaction through the metaphor of theatrical performance. According to this perspective, individuals who perform actions in everyday life are like actors on a stage.

Goffman further identified two ways in which people present themselves in society: (1) *the front stage* and (2) *the back stage*. Front stage behaviors are shown to audiences, while back stage behaviors mainly occur when audiences are not around. In the front stage, the performer is on display and constrained to maintain their roles, which is called "impression management". Since the back stage is outside the public eye, it is the region where the front stage performance is prepared. It also provides opportunities for the actors to relax, rehearse, and recharge (Hviid et al., 2015).

The performative interaction model proposed by Goffman can help us to understand the issue of "social embarrassment" that has been frequently observed in field studies with IPDs. Some people were found to be reluctant to use IPDs because they felt humiliated and anxious, especially when they were expected to perform gestures in front of other people (Perry et al., 2010; Brignull & Rogers, 2003). However, for some people who have the desire to highlight their roles in public spaces, IPDs can also provide opportunities for showing off (O'Hara et al., 2008).

Goffman's later studies continued the themes of dramaturgy and provided a deeper understanding of face-to-face interaction in public spaces. In the book "Behavior in Public Places" (1963), he defines a series of concepts and rules to describe social interactions in public spaces. Two kinds of social interactions in public spaces are identified: (1) "*unfocused*" and (2) "*focused interactions*". Unfocused interaction is the dominant kind of communication in most public areas. It occurs when people pursue their own concerns in the presence of others. In this realm, there is no official center of attention. Focused interaction occurs when people are gathered and openly collaborate to sustain a shared focus of attention (Hviid et al., 2015). According to Persson (2018), unfocused interaction is characterized by the presence in a shared situation, while focused interaction emphasizes mutual involvement.

The concern of "gathering" led Goffman to further explore the social relations between people in public spaces. In the book "Relations in Public" (1971), he identified the social state as being either "*singles*" (individuals) or in a "*with*" (pairs or groups). He argued that people would behave differently if they were in a different state. Generally, people feel more comfortable in "single" conditions and they prefer to maintain "unfocused interaction" in public spaces mainly because of the needs of private spaces. Although people are always in the "front stage" within public places, "unfocused interaction" allows them to attend to their own business. In this way, they don't need to consider others too much unless they transform "unfocussed interaction" to "focused interaction".

2.6.2 Social Experience around IPDs and Design Strategies

The term of social experience in public spaces has been mentioned in many previous studies. It describes how people perceive themselves and others in public social situations, which leads them to perform certain actions.

Based on Goffman's performative interaction model, Dalsgaard & Hansen (2008) articulated that users of public systems can be engaged in three kinds of acts simultaneously: (1) *the act of interacting with the system*, (2) *the act of perceiving the relations between them and the system and the relations between them and surroundings (e.g., other people)*, (3) *the act of performing for others to observe*. Similarly, the users of public systems can play three types of roles simultaneously: (1) *operator*, (2) *spectator* and (3) *performer*. (1) The concept of the operator is relative to the system. It refers to the people who directly interact with the system; (2) Spectators are the people who observe the interaction between the operator and the system. (3) The concept of the performer is relative to spectators. When people's acts become possible for others to observe, they are perceived as performers.

Through extensive analysis of several cases, Dalsgaard & Hansen (2008) argued that the users of public systems are aware of their roles. The awareness shapes their perception of interaction and is important for their social experience in public spaces. The three kinds of roles and acts can mutually influence each other and transform into each other, in both intrinsic and extrinsic ways. For example, in the case of an IPD application "Opinionizer", Brignull & Rogers (2003) found that the operators and performers standing in the vicinity of the display tended to attract more spectators (the extrinsic way), and the spectators might later become operators and performers (the intrinsic way). People gathered around the display seem to give a tacit signal to others that they were open to focused interaction. This phenomenon was first described as the "honey pot effect" by Brignull & Rogers (2003), and it was reported in many later field studies of IPDs (Jacucci et al., 2010; Wouters et al., 2016).

Based on the concept of performers and spectators, Reeves et al. (2005) argued that public systems should be designed not only for operators but also for the experience of spectators. They deconstructed interaction into

"*manipulations*" and "*effects*". Manipulations refer to the actions carried out by operators such as physical controls, gestures, movements and speech. Effects are the sensible output of the system such as the displayed images and sounds. Reeves et al. (2005) presented a taxonomy to classify the public interfaces according to the extent of the effects resulting from performers' manipulations, which includes *hidden*, *partially revealed*, *fully revealed* or *amplified for spectators* (Figure 2-7). To enhance the honey pot effects, they further proposed four design strategies based on the taxonomy: *secretive* (hide the manipulations and effects), *expressive* (reveal both), *magical* (hide the manipulations but show the resulting effects), *suspenseful* (show the manipulations but reveal the effects only when spectators turn to performers).

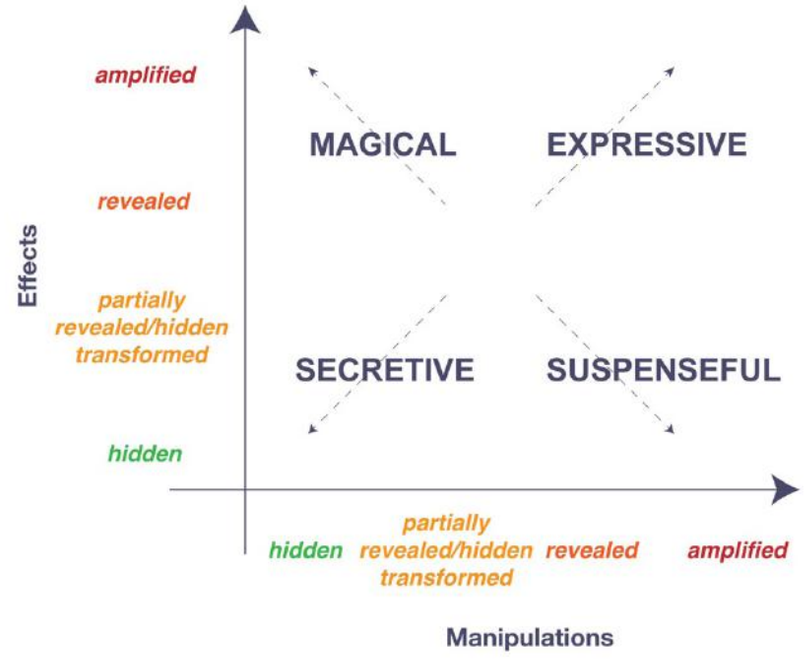


Figure 2-7 Four design strategies of designing the spectator's view (Reeves et al., 2005)

2.6.3 Social Interactions around IPDs and Design Strategies

In the past decades, different types of social interactions around public systems have been identified in many previous studies. Numerous researchers have discussed and categorized them from different perspectives. Some of them also proposed related design strategies for various social interactions, which can inform the design in related fields.

Terrenghi et al., (2009) argued that the design of IPD applications should vary as to whether there is equal access to the display. Regarding the nature of social interactions, they distinguished five kinds of interaction and sharing caused by IPDs. They are (1) *one to one* (single person), (2) *one to few* (approximately three to nine), (3) *few to few*, (4) *one/few to many* (more than ten people), and (5) *many-many interaction*. Corresponding examples are UbiTable (Scott et al., 2004), Pick-and-drop (Rekimoto, 1997), WeSpace (Jiang et al., 2008), Wray Photo Display (Taylor et al., 2007), tune_eile (O'Murchu, 2008).

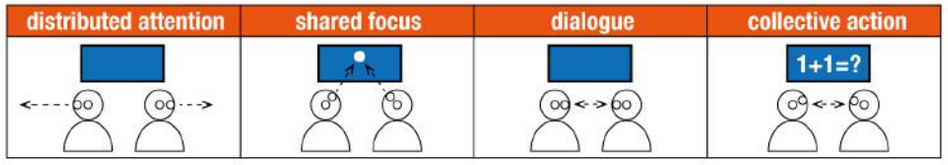


Figure 2-8 Four types of interaction in public spaces (Ludvigsen, 2005)

Since most IPD applications are considered to be either task-oriented (e.g., UbiTable and Pick-and-drop) or experience-oriented (e.g., tune_eile), Ludvigsen (2005) pointed out that social use is also an important aspect to design technologies in public spaces. Based on Goffman's work mentioned above and the empirical design research on a case called "iFloor" (Krogh, 2004), he proposed a conceptual framework of social interaction in public spaces to facilitate the design of related technologies. The framework consists of four types of interaction (Figure 2-8): (1) *distributed attention*, (2) *shared focus,* (3) *dialogue* and (4) *collective action*. They are structured along a scale of engagement. (1) Distributed attention means people present in the same place but with their own concerns. (2) Shared focus refers to the situation where people share the center of their attention. (3)

Dialogue occurs when people are engaged in shared activities by exchanging information (verbal or non-verbal). (4) Collective action is similar to dialogue but with a stronger emphasis on working collaboratively for a shared goal (Ludvigsen, 2005). This conceptual framework provides a tool for designers to predict whether the introduced systems will affect different levels of social interactions in public spaces, and to what extent the system can support the users to select their social interaction to a different level.

Hespanhol and Dalsgaard (2015) argued that previous contributions in this field mainly addressed the social aspects of public systems in singular or few cases. Therefore, they analyzed 50 case studies and categorized three broad groups of social interaction modes around public systems: (1) *spectacle*, (2) *creativity*, and (3) *conversation*. (1) Numerous public systems were designed to display spectacle to attract passers-by. People can either passively watch together (appreciation) or actively express themselves via performing (self-expression). Typical cases in the spectacle are Body Movies (Lozano, 2001) and MyPosition (Valkanova, 2014). (2) In the domain of creativity, one common way to stimulate social interaction is creating a playful experience. Numerous cases, such as Aarhus By Light (Dalsgaard & Halskov, 2010), have indicated that playfulness can largely change ordinary street practices and reduce social constraints between strangers. Another way is to enable simultaneous interaction by multiple people, which was called "collective narratives". (3) Conversation (verbal and non-verbal) is difficult to stimulate between strangers in public spaces. Hespanhol and Dalsgaard (2015) pointed out that conversations emerge from a mutual interest in the displayed content, which is an effect known as triangulation (Whyte, 1980). If people are always in sight of each other, negotiation of space can be found around IPDs according to established social rules, as shown in the case of Solstice LAMP (Hespanhol & Tomitsch, 2015). Based on the social interaction modes, Hespanhol and Dalsgaard (2015) further identified seven design strategies (Figure 2-9): *shadow playing*, *remote control, smooth operator*, *soapbox*, *amusement park*, *swarm*, and *automatic gate*.

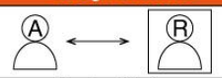
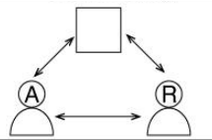
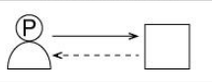
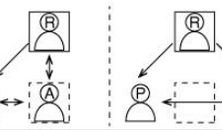
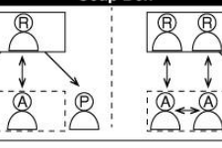
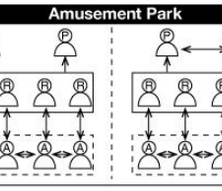
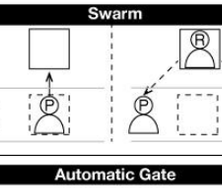
Design Patterns	Feature	Example
 Shadow Playing	• spatial layout: plaza • full-body interaction and direct feedback • 1-to-1 relationship between individuals and representation	• Body Movies • Aarhus By Light • Solstice LAMP
 Remonte Control	• spatial layout: plaza • a tangible user interface as a mediator • centralized or distributed devices	• SCSD • iRiS
 Smooth Operator	• spatial layout: thoroughfare • responding to movements of passers-by • delayed feedback to full-body tracking	• Chromapollination • The Climate on the Wall
 Soap Box	• enticing individual expression and its appreciation	• MyPosition • The Climate on the Wall
 Amusement Park	• promotes a wide array of social interaction (spectacle, creativity and conversation)	• Solstice LAMP
 Swarm	• spatial layout: plaza • people interact via triangulation with the display, negotiating the physical space in the process	• Solstice LAMP Interference
 Automatic Gate	• spatial layout: thoroughfare • create environments with varying levels of playful feedback and appreciation yet no room for self-expression or collective narratives	• Interference • Chromapollination • The Climate on the Wall

Figure 2-9 Design patterns of Urban Media Architecture for Social Interaction (Hespanhol and Dalsgaard, 2015)

2.7 User Involvement in Designing Technologies for Older Adults (RQ4)

Global population aging and the rapid development of novel technology lead to increasing demand for novel technologies to enhance older adults' quality of life by promoting their independence and social wellbeing. However, using modern technology was found to be a minority activity among older adults (Selwyn et al., 2003). Although recent studies revealed a growing rate of adoption, it is still limited and researchers found that elderly people still face many barriers in using technology because of issues related to familiarity, willingness to ask for help, trust in the technology, privacy, and design challenges (Fischer et al., 2014). Designing technologies that are acceptable, easy to use and attractive for older adults can be challenging mainly due to the lack of mutual understanding. From the perspective of Human-Computer Interaction (HCI), one important reason is the lack of effective design methods to bridge between two spaces - the world of engineers / designers / researchers, and the world of the end-users (Muller, 1997). In the 1990s, many conventional design practices were one-directional (Muller et al., 1993). They mainly depended on the professional skills and experiences of designers that were effective in generating ideal concepts and prototypes in general cases. But such low involvement of end users may cause some generational or age-related issues. Most designers of new technologies are able-bodied and from the younger generations, which may lead them to make design assumptions based on their own cognitive and physical ability. Moreover, although there have been some tools that can help younger designers experience the physical or mental condition of older users, the age-related social, emotional and environmental factors are difficult to be simulated during the design process. Therefore, a mismatch can easily occur between designers' proposals and the real needs and capabilities of older users, which may largely explain older people's reluctance to interact with many emerging applications.

Sanoff (1990) suggested that any design aiming at improving the quality of users' everyday life should consider participation through user involvement. In the past decades, we have witnessed a design movement where the attitude is shifting from "designing for users" to "designing with users". Since traditional design methods might not be sufficient to develop acceptable and

adoptable technologies for older people, methods such as User Centered Design (UCD) and Participatory Design (PD) are increasingly applied to develop successful technical solutions for seniors. However, although there has been plenty of research in the design approaches to involve end users, it is difficult to find standard definitions of these methods acknowledged by all the research communities. According to the ISO standard of "Human-centered design for interactive systems", PD is one of three design solutions of UCD, but many researchers argue that they are different approaches although there is some overlap (Sanders, 2002). Furthermore, these design approaches are usually adopted as general design philosophies rather than as a fixed methodology. In specific design practices, users are involved in various forms and degrees. Therefore, rather than distinguishing between these design approaches, the RQ4 of the research in this thesis focuses on exploring how to involve nursing home residents to contribute to the design of IPDs for their social interaction.

There have been numerous studies involving older people in designing technologies, most of which are presented as case studies. Šabanović et al. (2015) presented a project to develop socially assistive robots with the elderly diagnosed with depression. They found that older adults were willing and had the ability to be involved in the design process, but also that conventional hands-on participation might be a challenge. Wilkinson et al. (2014) explored how to involve older users in the process of commercial product development through designing an intelligent mobility aid and wheelchair. They addressed the importance of including elderly users during the early discussions to facilitate new concept generation. Veldhoven et al. (2008) focused on designing acceptable assisted living services for the elderly and presented a design vision by illustrating three cases. They summarized three main barriers for elderly users to use new technology: complexity and learnability; lack of perceived benefit; and compatibility issues. Seale et al. (2002) explored the use of the focus-group method to help older adults identify their mobility-related problems and put forward new ideas. They found that the participants were able to propose existing and new solutions, but the composition and process of the methodology should be further developed by validating the choice of tools. Kanis et al. (2011) conducted a preliminary study to design ambient assisted living systems for monitoring the daily activities of elderly residents, which proved that traditional use-

centered design methods could hardly help older adults visualize ambient assisted living scenarios.

Regarding specific techniques of involving older people in design processes, organizing group design activities such as future workshops and brainstorms were common solutions. Besides, video demonstration was frequently used to quickly provide a concrete vision for older people via showing existing solutions and illustrating future scenarios (Šabanović et al., 2015; Iacono et al., 2014). It can also provoke creative responses and critical discussions (Raijmakers et al., 2006; Lindsay et al., 2012). Some studies also found that hands-on techniques, though some of which were challenging for older adults, were more successful than verbal explanations or demonstrations. Conventional hands-on techniques include sketching, card sorting, collage, paper prototyping, etc. Some studies also explored novel techniques by providing live demos and creating interactive simulated scenarios to actively engage the participants (Kanis et al., 2011). The prior work in this field has indicated the necessity and feasibility of involving older people in developing new technologies. Although early studies and practices provided many implications, their ways of involvement were customized based on their own design and context. Therefore, our study also aims to explore a feasible and proper way to involve nursing home residents in designing IPDs for their social interaction.

2.8 Summary of Takeaways

In this chapter, we first introduce the contextual background of this thesis. Our research was conducted in the contemporary Dutch society that is ageing more and more rapidly. According to the official statistics, the existing nursing homes can barely satisfy the rising demands. However, due to the budget and related policies, very few new care facilities can be established in the short term, which revealed the importance of designing technologies to enhance current nursing environments. Besides, due to the insufficiency of care institutions, only the older adults with poorer self-care abilities could be accepted by most Dutch nursing homes. Since this user group puts relatively higher requirements on their surroundings and daily items, more research should be conducted to investigate which kind of technologies should be designed and how to design these technologies.

Then we examine the previous explorations of socio-technical interventions in nursing homes. It shows that most social technologies that have been widely applied in practice were designed as caregivers' tools in social interventions. The social effects of such technologies can be easily limited by the form of social programs. In the research field of human computer interaction, great efforts have been paid to design socio-technical systems in residents' private rooms. Since public care environments are important areas for residents' social wellbeing, we believe it is essential to investigate which kind of public systems are suitable in such context and how to design them. However, there are few in-depth studies in this field for us to refer to. Given this, we commence the field research with an explorative case study (Chapter 3) to provide a research baseline. By deploying a functional public display system in a real-world setting, we aim to obtain initial implications that can be iteratively validated in the following research phases.

Last but not least, we provide a brief literature review corresponding to the four aspects of my research questions (design factors, interaction models, social aspects, and user involvement). As indicated above, there have already been plenty of studies in each aspect. These previous studies can not only guide our design but also help us better answer the research questions. However, as we can see from this review, few of them have specially discussed the adaptability of their findings to nursing environments and

older adults. Based on this, our research questions can be answered from the following perspectives:

In terms of design factors, the common factors are summarized to be mental models, display forms, interaction techniques, context, and external factors. Are these factors also important in designing IPDs for nursing home residents? If so, which decisions should we make to optimize these factors, and are there any other important factors?

In terms of interaction models, five main models are introduced to demonstrate interaction process of users around IPDs. We find that all of them are conceptualized from conventional standalone IPDs in other contexts, such as bars and city squares. Can they also be applied in nursing environments? If so, will nursing home residents also engage with IPDs as these models describe?

In terms of social aspects of IPDs, we know that Goffman's "dramaturgical theory" has deepened our understanding of people's social interaction in public spaces and influenced later studies on IPDs. Can these studies also explain nursing home residents' social perceptions and behaviors around IPDs? If so, how will they perceive such experiences and which kinds of social interaction will be affected by IPDs? And, among the design strategies introduced, are there any of them suitable to be applied in this context?

In terms of user involvement, numerous studies have indicated that it is necessary and feasible to involve older people in the design process of new technologies. But it is still unknown that, when designing IPDs for nursing home residents' social interaction, in which stages should residents be involved? In which forms should they participate in the design activities? And, which design techniques are suitable to be adopted?

All these questions are what we aim to find out through the following design studies.

纸上得来终觉浅，绝知此事要躬行。

The Knowledge gained from books is plain, must practice to truly grasp it.

– 陆游 *Lu You* AD 1199

Chapter 3.
The Case Study of OutLook

3.1 Introduction

As indicated in Chapter 2, although there is plenty of research in designing IPDs and designing socio-technical interventions for older adults, the research and practices in designing IPD systems in public care environments are scarce. Due to this lack of foundations to work on, the field research of this thesis commenced with a factor-finding case study of "OutLook". It is part of a participatory system called "ViewBricks & OutLook" that is specially designed for nursing home residents to enhance their social wellbeing through a "look-outside" and a "postcard-sending" metaphor. This project was collaboratively explored with two other PhD candidates (Xu Lin and Cun Li) with different research emphases. When I first joined this team, my research interests were in the social potential of IPDs in nursing homes and the related design factors, but the detailed research questions presented in Chapter 1 had not been explicitly formulated. Therefore, on the one hand, my focus in this project was to investigate the effects of OutLook on residents' social interaction and gain initial insights on the design factors. On the other hand, the implications derived from this case study could make my PhD research questions more explicit and complete. In this chapter, I will use "we" for the shared work, and "I" for my analysis. Firstly, I describe our design process of OutLook. Then, I report a six-week field trial that we performed in a Dutch nursing home. This study showed that IPDs can have positive social impacts on residents' behaviors and feelings. From this study, I preliminarily identified some key design factors along with related guidelines. Besides, lessons and implications on user engagement with IPD systems and user involvement in the design process were summarized, which further constructed my PhD research questions. Part of this Chapter has been published as an article in *the Journal of Ambient Intelligence and Smart Environment* (Kai Kang et al., 2018).

3.2 Design Process

3.2.1 Contextual Investigation

Since the team members had similar research topics on designing for older adults' social wellbeing, and we all planned to adopt "research-through-design (RtD)" as an overall approach, we aimed to conduct this collaborative project by designing a specific system in a specific environment. Therefore, we chose a typical Dutch nursing home located in Eindhoven. A contextual investigation was conducted to have a basic understanding of the care environments, residents' daily habits and their social lives.

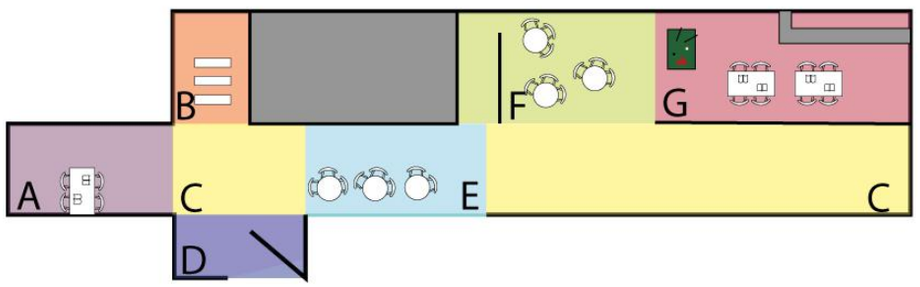


Figure 3-1 The layout of the public spaces of the nursing home (A: Reading area, B: Library, C: Hallway, D: Gate, E: Leisure area in the hallway, F: Leisure area next to the canteen, G: Canteen)

This nursing facility is part of Vitalis Care Group, which is a professional organization providing living, treatment and care services for the elderly. The nursing home consists of private rooms, public spaces and close areas for dementia patients. The public spaces include a restaurant, a library, a hallway and several leisure areas to satisfy the daily demands of residents (Figure 3-1). Programmed activities and multiple levels of care, including independent living, assisted living and behavioral care units, are also offered.

3.2.2 Informal Observation

Figure 3-2 The nursing home residents spent hours to sit and look through the window every day.

To get a basic understanding of residents' daily activities within public area, unstructured observations were conducted by two researchers (Cun Li and Kai Kang). We didn't have predefined items or activities to observe. We walked around the public areas (Figure 3-1) during the period of 8:00 AM to 6:00 PM for one week. For privacy and ethical issues, video recording was not allowed by the nursing home. The observers could only take field notes or take photos with residents' permission. At the end of the week, the notes were compiled into a report. According to the report, many residents stuck to regular daily routines. "Always the same group of people did the same thing at the same place." One observer recalled afterwards. The canteen (Area G) and the leisure area in the hallway (Area E) were the preferred public spaces. Although there was an age-oriented mini library and a reading area, few residents spent time there. They often chose to sit in the canteen reading newspapers and magazines. The canteen not only served as a place for eating and drinking, but also was a primary area for entertainment like games and organized activities. The leisure area in the hallway was another popular place with a large window through which the elderly could look outside. We found a very common phenomenon that many residents spent hours simply looking outside (Figure 3-2), which later became one of our design inspirations. The leisure area (Area F) next to the canteen was much less popular. This was where the residents wanted to stay when they had family visits because this area was relatively quiet and suitable for private conversations. Most of the residents just passed this area to enter the canteen from the hallway.

3.2.3 Informal Interview

We firstly conducted informal interviews with eleven residents. The main objectives were to have a general understanding of their daily habits, social lives, and use of technologies. However, due to the language barriers and lack of experience in interviewing older adults, the information collected at this stage was limited. The interview mainly indicated that all the residents stick to different but very stable daily routines. Although they often met each other, the interactions and relationships between most of them were very superficial. The organized activities were almost the only way for them to have further communications with their peers. But many residents complained that the themes didn't meet their interests. They mainly relied on the occasional phone calls and visits to maintain their family bonding, which was not enough to satisfy their social need. Besides, most of them suffered from physical or mental degradations, which prevented them to learn new technologies.

To have a further understanding of residents' daily lives, we also interviewed two caregivers. They said there were about 250 residents in this nursing home, among which about 130 residents were under assisted living care services. These 130 residents usually spent their day within the boundaries of the nursing home. Although there were social activities planned every week, most of the residents had to entertain themselves during the rest of their time. From the perspective of the caregivers, many residents were unwilling to go to the public spaces to interact with others even when they barely had things to do in their rooms. To encourage them to join the activities, the caregivers often sent invitations through their mailboxes. They observed that many residents experienced loneliness especially when they had physical problems, or after family visits. Besides, the very stable social groups in the canteen established long time ago made it hard to join for others, while the leisure areas were more open to newcomers. Generally, the interview confirmed the results of many previous studies (Gottesman and Bourestom, 1974; Ice, 2002; Ouden et al., 2015) and our assumptions mentioned in the introduction.

3.2.4 Brainstorm Session

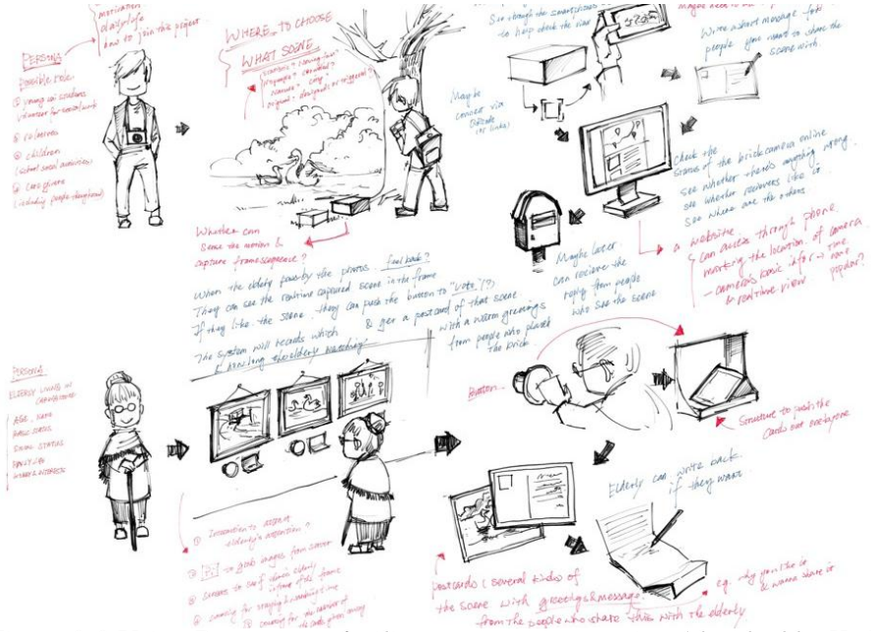


Figure 3-3 Using Personas to facilitate concept generation (sketched by Xu Lin)

Based on the preliminary investigation mentioned above, we assumed that a public system could be designed to attract more residents and promote their social interaction. Hence, we conducted a brainstorm session to generate a proper design concept. Five experienced designers participated in this session. Pens, colored markers and blank papers were provided to facilitate writing and sketching. To begin with, we created personas (fictional characters) based on our findings, which could help the participants understand users' needs, experiences, behaviors (Cooper & Reimann, 2003). During the session, looking out the windows was identified as a behavior that indicated residents' monotonous experience in public spaces and their desire to connect with the outside world. Therefore, we reached a consensus to design "magic windows" that could provide different views of the outside world. We hypothesized that, to achieve this, younger people, such as students, young volunteers and caregivers, could be involved as sources to provide views via customized camera kits (Figure 3-3). We also proposed various interactive features embedded in the "magic windows" to attract residents and trigger their discussions (Figure 3-3).

3.3 Concept and Prototype Design

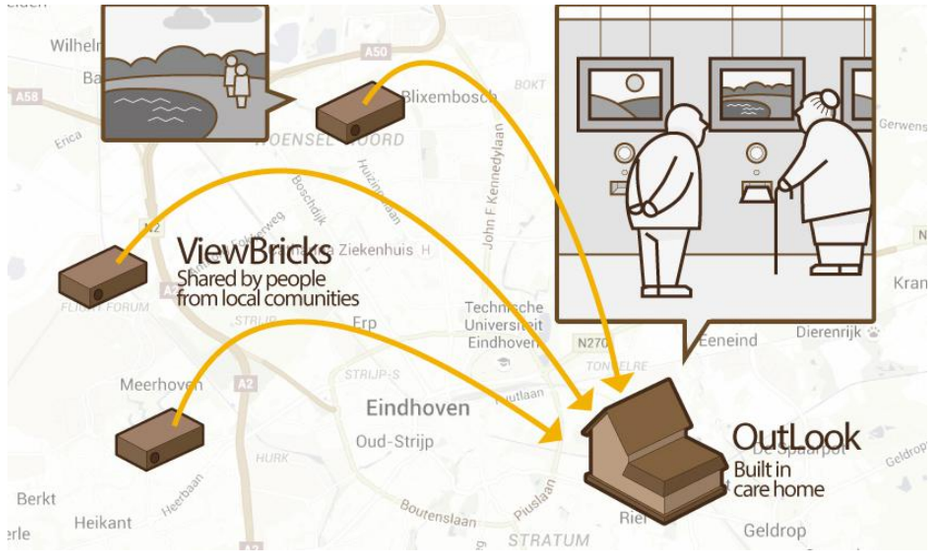


Figure 3-4 The overview of the smart participatory system: ViewBricks and OutLook

The final concept is shown in Figure 3-4. The system consists of two parts: one is a group of camera kits called ViewBricks to be used by younger people outside nursing homes to share real-time image sequences from different locations. The second part is OutLook, which is a series of gallery-like public interactive displays. OutLook continuously displays the content sent from ViewBricks in the ambience of the public spaces of care homes and triggers further social interaction of residents through a "postcard-sending" metaphor.

Our motivation of designing this system was to make some differences of residents' repetitive life, trigger their social interactions and enhance their feelings of connectedness. As mentioned above, the interactive public displays could be a platform to connect people by breaking space, time and social barriers. OutLook was inspired by the residents' habits of looking out through the windows in our preliminary study. Due to their physical degradation, many of them could hardly go long-time traveling or to a far destination. OutLook would be a way to bring the outside world into

the nursing home by displaying real-time images. We also hoped social interactions could not only be triggered when the residents watch together, but also be sustained by the physical sharing of postcards. Figure 3-5 shows the prototype that we implemented for the following field trial. The technical specifications can be found in our paper published in proceedings of the 12th International Conference on Intelligent Environments (Lin et al., 2016).

Figure 3-5 The prototype of one of three OutLook and Viewbricks

People from local communities, such as students and office workers living in the neighborhood, are recruited to adopt a ViewBrick and encouraged to put them where they would like to share. All they need to do is to turn on the camera kits, set the lens towards the view and then leave. The ViewBricks would then keep taking photos and upload these images automatically (one picture per minute) to a private cloud server (Figure 3-4). In the public spaces of a nursing home, OutLook keeps displaying the image sequences received from the cloud server and displaying them in an ambient way. It can detect the presence of nursing home residents passing by and attract them by playing a time-lapse animation to demonstrate the changing sceneries from the last two hours (Figure 3-6). If the residents enjoy the real-time view, they

can choose to print it as a postcard by pressing the button under the display and share it with others (Figure 3-7).

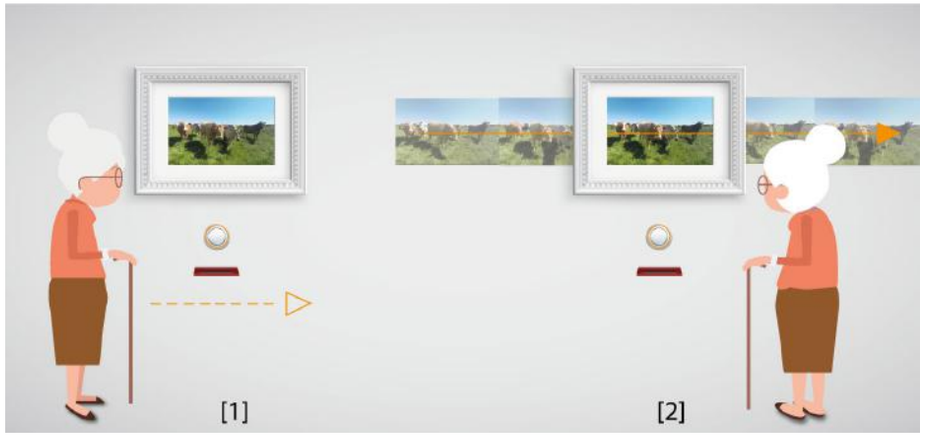


Figure 3-6 OutLook would start a time-lapse animation when it detects people standing in front of the frame, showing the scene change in the last two hours.

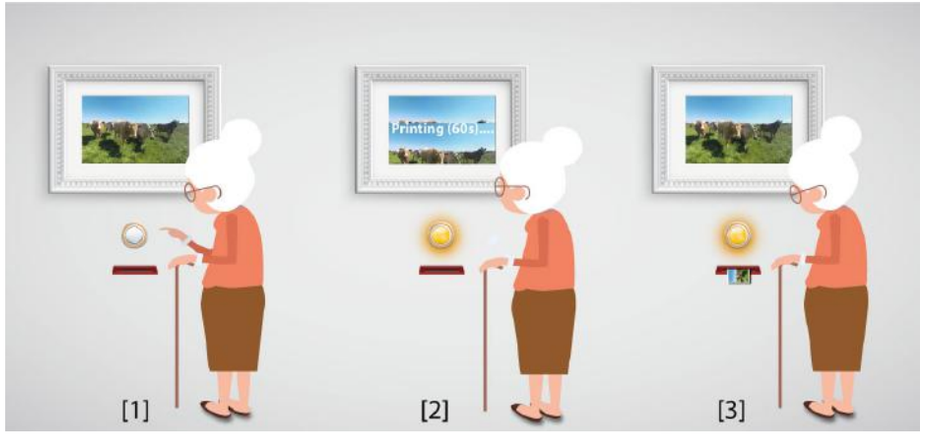


Figure 3-7 From digital sharing to physical sharing by pressing the button of OutLook

3.4 Field Trial of OutLook

3.4.1 Procedure

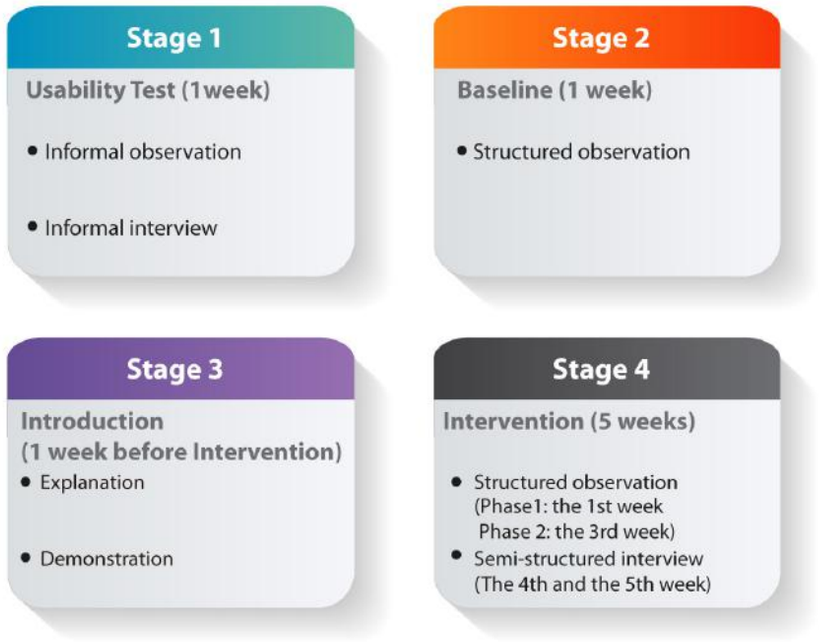


Figure 3-8 An overview of the research procedure

A field trial was conducted mainly to investigate the social effects of OutLook in the public spaces of the nursing home. It consisted of four stages: (1) Usability Test, (2) Baseline, (3) Introduction and (4) Intervention (Figure 3-8).

Before OutLook was installed in the nursing home, it was tested in the public space of the Industrial Design Department of TU/e (Eindhoven University of Technology) for one week. This test was mainly focused on usability. We put ViewBricks in a little park of the campus to collect images. To simulate the context in the nursing home, OutLook was put in the corridor between the canteen and offices where staff and students usually passed by. The system kept running at least two hours a day during working hours. Informal observations were conducted to identify possible problems. Besides, we

invited eight nursing home residents to come and experience the prototype. Informal group interviews were conducted to get their initial feedback including usability, user experience and location preferences. However, we found most participants were influenced by the new environment, and they didn't pay enough attention to the prototype. Therefore, such a pretest was not very informative. We could only refine some minor usability issues based on the results of the observation and interviews.

The Usability Test was followed by the Baseline. The purpose of the baseline was to collect residents' behavior data in Area F through structured observation. In this stage, we recruited the same observers from the preliminary study because they were familiar with the context. They were provided with a check sheet to record residents' behavioral data (Figure 3-12). The observation lasted one week from 2:00 PM to 4:00 PM every day because it was the period when most of the residents came to the public spaces for entertainment.

Figure 3-9 The nursing home residents trying OutLook during the Introduction.

After the Baseline, OutLook was installed during the night to not interfere with residents' daily life. Given most residents spent most of their time

in private rooms and many of them had limited acceptance and ability to use new technology, we hosted an introduction activity one week before Intervention. Based on the statistics provided by the caregivers, we sent 130 invitations through the residents' mailboxes. The invitations said that they were invited to a tea party downstairs in Area F. At this party, a group of (Dutch-speaking) students from TU/e would introduce a new system specially designed for them. Twenty-two residents came to this activity. The whole session lasted from 2:00 PM to 4:00 PM. It started with an explanation of the design concept and a demonstration of typical scenarios. After that, the residents were encouraged to ask questions and experience the prototypes (Figure 3-9).

The Intervention started one week after the Introduction and lasted five weeks in total. We kept the system running from 1:30 PM to 4:30 PM every day in this stage. The structured observation was conducted by the same observers with the same measurements as the Baseline (from 2:00PM to 4:00PM). In order to investigate how the effects would change as time passed, the observation consisted of two phases. Phase 1 started from the first week of Intervention, and Phase 2 started from the third week. In the following two weeks after the observation, the interviewers (my colleague Xu Lin and a student assistant) were guided by the observers to find as many users as they could to participate in the interview.

3.4.2 Setup

Location: In order to maintain consistency, we decided to install OutLook in the nursing home where we conducted the preliminary study. We chose to install it in Area F (Figure 3-1) against the wall facing the canteen (Figure 3-10). This location was selected based on the preliminary study. Firstly, although Area F was initially set up with tables and chairs for residents to stay, we found it mainly served as a main thoroughfare to the canteen. Secondly, since we adopted the bodily and direct interaction techniques, this area had relatively more room for residents to walk around OutLook. Furthermore, since Area F used to be less popular, we believed that it was helpful for residents to communicate with less external factors such as noise and their previous relationships. What's more, the impact of OutLook would be clearer

to be observed in such an environment.

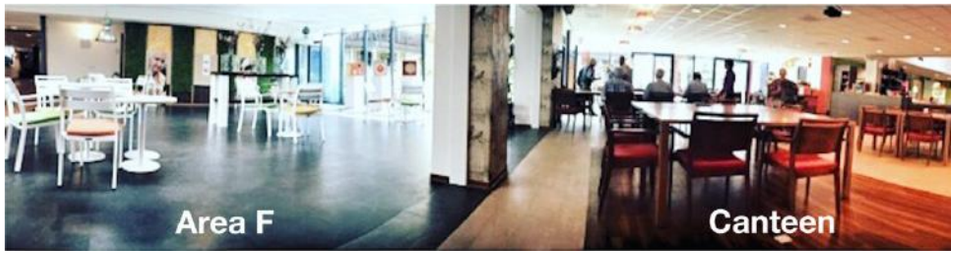


Figure 3-10 The observation area (Area F) and the Canteen

Interface: Considering the technology acceptance and ability of most residents, the physical interface was designed like a gallery with three white photo frames. The digital interface was designed to be simple and clear: Most of the time, OutLook just displays the latest updated image. When it plays the time-lapse animation, captions such as "*Two hours ago…*" are included in the lower-left corner. When a user presses the button, a light inside the button is turned on, and another caption "*printing the postcard*" is displayed with a countdown clock for 60 seconds.

Content: Although in the original design concept ViewBricks would be assigned to random local people, it was the research assistants who shared the views with ViewBricks during the field trial. Three themes (animals, people and landscapes) were chosen to appeal to the nursing home residents with different preferences (Figure 3-11). The ViewBricks were put in three typical local places including a farm, a university and a park. For privacy and security reasons, the cameras were located far from people so that their faces could not be recognized.

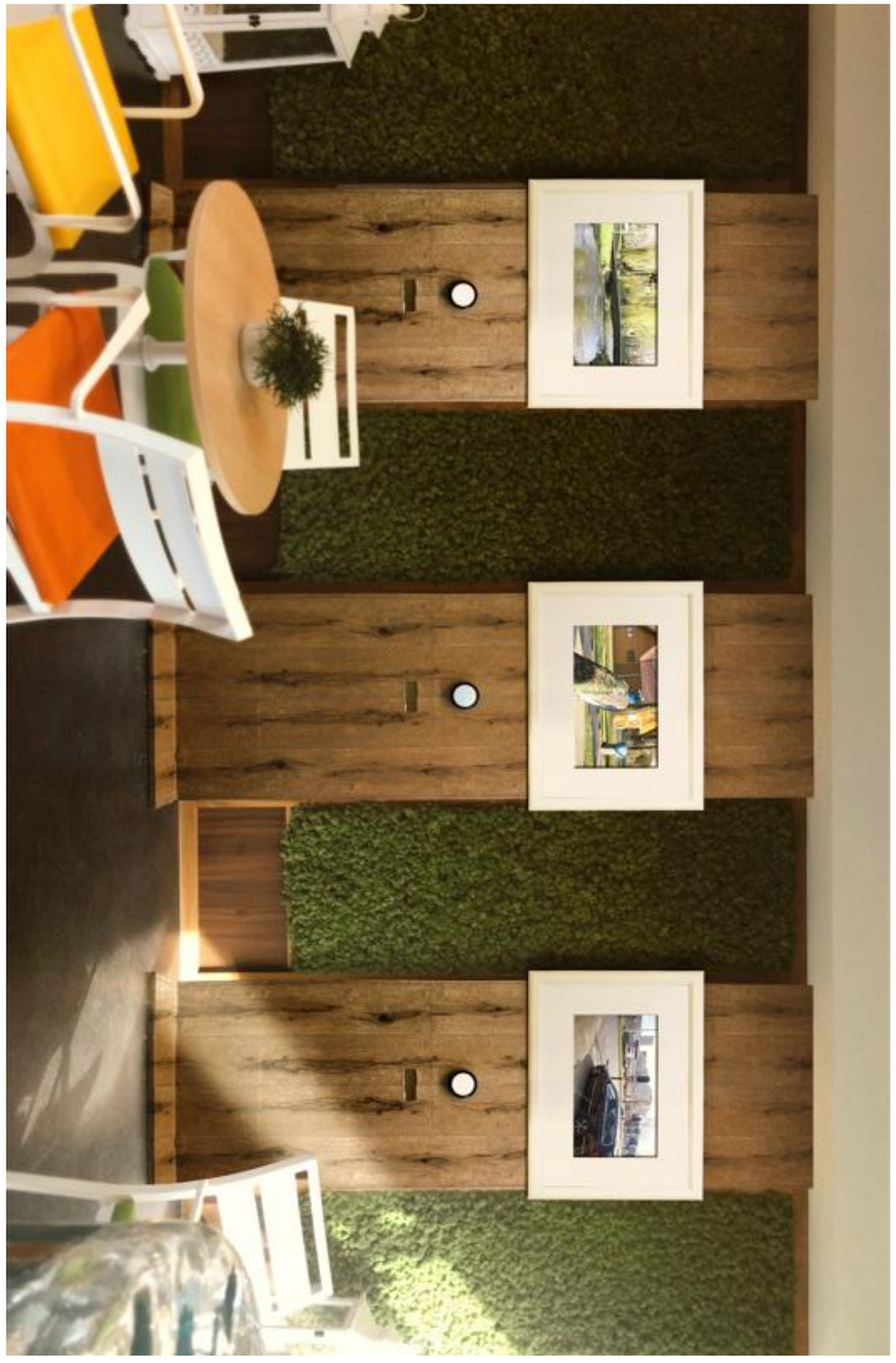


Figure 3-11 The prototypes of OutLook in Area F display different themes (animals, people and landscapes)

3.4.3 Measurement

We designed OutLook with the following hypotheses: after OutLook was installed in Area F:

(1) *More residents were expected to stay in this area.*

(2) *The residents were expected to stay longer in this area.*

(3) *The residents were expected to spend more time in social interactions in this area.*

(4) *The residents would feel more connected, not only to each other, but also to outside people and locations.*

To verify our hypotheses, objective and subjective measures were adopted. Structured observation was adopted to measure the residents' behavior change. Baseline observation and intervention observation were conducted to compare their behavior before and after OutLook was applied.

To gather residents' real reactions to OutLook, we did the observation in real-world settings rather than in a lab environment because of Hawthorne Effects, which indicated that people may behavior differently when they were aware of being watched (Taggart et al., 2005). Although much more completed and accurate raw data could be gathered by video recording, we collected the behavior data by taking notes out of ethical concerns (Repp et al., 1989).

To facilitate the process of data collection, we developed a check sheet (Figure 3-12) based on the study of McClannahan and Risley (1975). To avoid disturbing residents' activities in this area, the observers kept sitting at the corner of the canteen. Based on the report of the preliminary study, we summarized their basic daily behaviors and potential interaction behaviors. These behaviors, together with the three displays and the tables in Area F were recorded as alphanumeric codes. After the one-week observation in the preliminary study, the observers could recognize most of the residents because of their repetitive daily routines. They were assigned pseudonyms for

identification. To record residents' detailed behaviors in the two hours, the interval between each note was one minute. Usually, in general observational studies, the interval is much longer because it is difficult for the observers to record multiple subjects' changing behaviors on such short notice (Ice, 2002). However, in this specific context, it was feasible because Area F was a much less popular space than the canteen or hallway (Figure 3-10). It was normally an empty space with a simple layout. Besides, most of the residents' behaviors were not complicated and their movements were slow (e.g., drinking, eating, looking out). Therefore, one minute was enough for the observers to take notes and gather detailed data.

We conducted post-trial interviews to investigate the effects of OutLook on residents' subjective feelings such as their use experience and social connectedness. To guide the interviewers, we set up an interview protocol including the following primary topics:

1. *How did the participants understand and use OutLook?*

2. *How did the participants rate their user experience?*

3. *Did OutLook bring new feelings and make them feel more connected to each other, the shared locations, or the view sharer?*

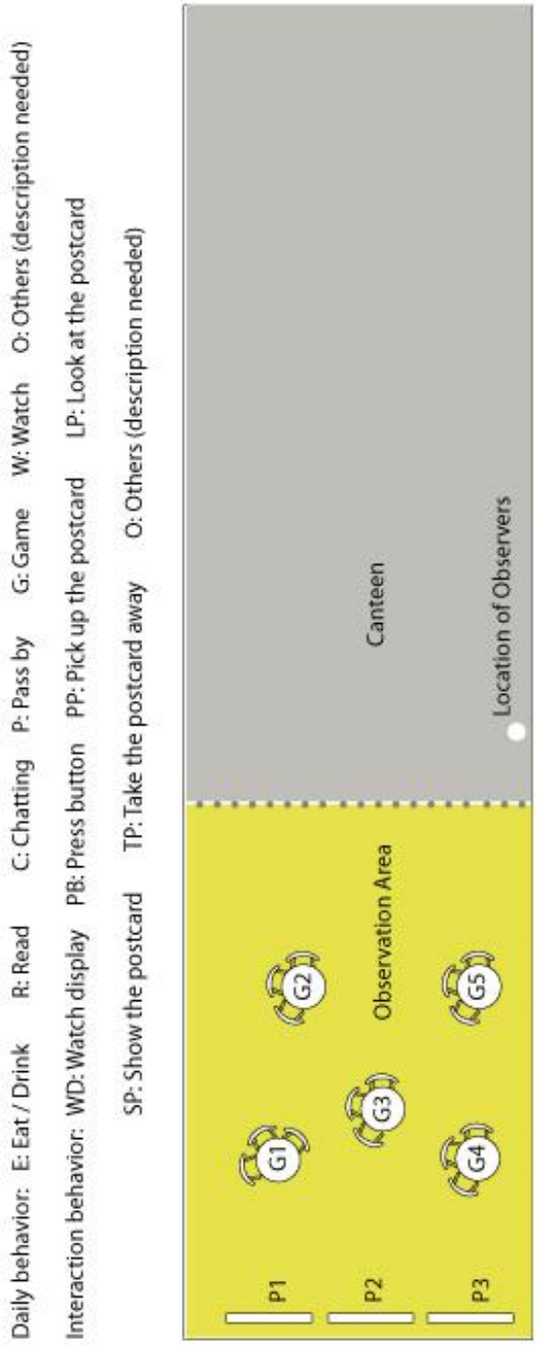


Figure 3-12 A sample check sheet for collecting behavior data

3.4.4 Result of Observation

- *Evaluation of the hypotheses*

Hypothesis 1: More residents were expected to stay in Area F.

To examine this hypothesis, the total number of the residents stayed in Area F through the observation period per day was compared between each session. Those who just passed this area or stayed less than one minute were not recorded. As shown in Figure 3-13 and Table 3-1, there was an overall improvement from the Baseline to the Intervention. One-way ANOVA was used to test if there were statistically significant differences between each session. From the comparison between the Baseline and Phase 1, there were significantly more residents coming to this area in Phase 1 ($p<0.05$). Although the average total number per day in Phase 2 still showed an increase than the Baseline, it was not statistically significant ($p=0.15$). Compared with Phase 1, the number started to decrease in Phase 2. It seemed that the attractiveness of OutLook started to decline after Phase 1. However, the decrease was not significant ($p=0.29$).

Besides the total number, we were also interested in how many residents stayed and used OutLook in Phase 1 and Phase 2 (Figure 3-13). The term 'use' means having stayed in front of OutLook watching the displays or having pressed the buttons. If we compare the percentage of the users in total number each day in the Intervention, the average percentage was 51% and no significance was found between Phase 1 and Phase 2 ($p=0.69$). Therefore, on average, over half of the residents in Area F had interacted with OutLook every day in the Intervention.

To sum up, the results show that OutLook can indeed attract more residents to stay in Area F. The influence was significant in the first half period of the Intervention but started to decline in Phase 2. On average, over half of the residents came to this area would be attracted to directly interact with OutLook.

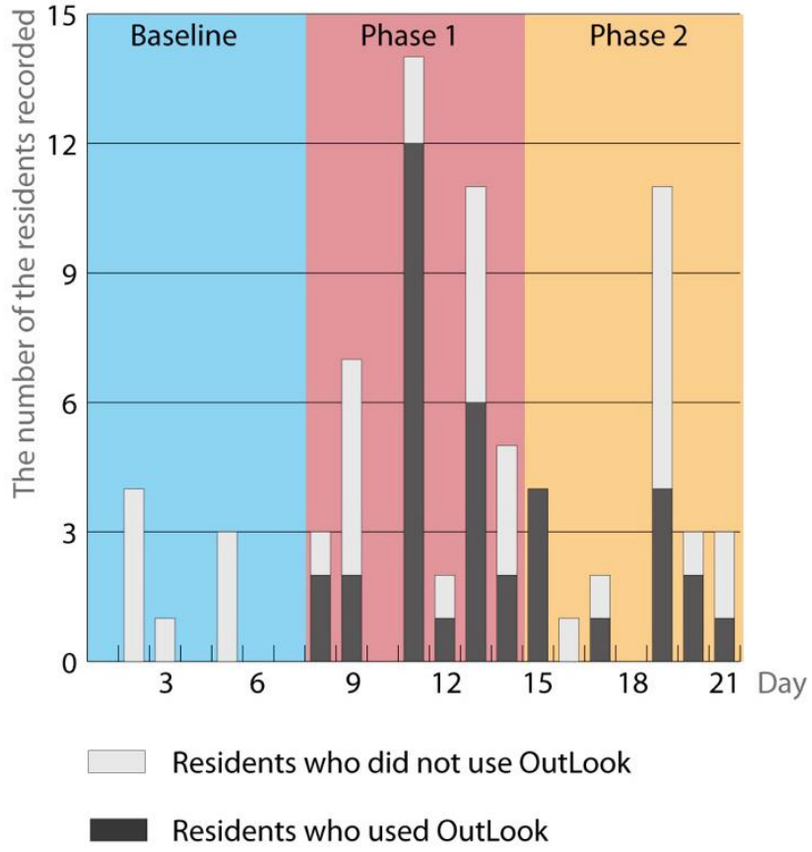


Figure 3-13 The total number of the residents stayed in Area F through the observation period per day in the Baseline and the Intervention

	Baseline	Phase 1	Phase 2
Sum	8	42	24
Mean	1.14[a]	6[b]	3.43[ab]
SD	1.68	5.03	3.6

Table 3-1 Sum represents the total number of the residents stayed in Area F through the observation period per week (min). Mean represents the average number on each day (min), and the letters indicate significant differences. SD represents standard deviation.

Hypothesis 2: The residents were expected to stay longer in this area.

The duration of the residents' stay in Area F can be calculated based on the observation logs. The total time spent by every resident in Area F throughout the observation period per day is shown in Figure 3-14. As can be observed in Table 3-2, similar to Hypothesis 1, the average time spent by the residents each day also had an overall increase from the Baseline to the Intervention. Unlike the attenuation trend in Hypothesis 1, the average amount of time in Phase 2 still kept rising, but the data in Phase 2 had a much higher standard deviation than the Baseline and Phase 1, which means there was a big difference between the data of different days in this session. According to the observers' notes, the sudden rise on the fifth day of Phase 2 was because a couple of residents sat in Area F, watching OutLook for much longer time than usual. Overall, the improvement in Phase 1 was close to reaching significance ($p=0.09$). No significance was found between Baseline and Phase 2 ($p=0.3$) or Phase 1 and Phase 2 ($p=0.6$). If we remove the data on the fifth day in each phase, still no significant difference could be found.

To further explore how the residents spent their time in this area, we were also interested in the proportion of their time spent on directly using OutLook. From Figure 3-14, we can find out the average proportion of the residents' time spent in using OutLook was 29.37% in Phase 1 and 17.19% in Phase 2. There was no significant difference between the two sessions ($p=0.55$).

So generally, although not stable, we can see an increase in the resident' time spent in Area F since the Intervention, which preliminarily support our hypothesis. However, they spent a small portion of their time on directly using OutLook. Although we assumed some residents may spend their time on watching OutLook at a distance (as the couple of residents did on the fifth day of Phase 2), we could not directly conclude from the observation. This assumption may be confirmed in the interviews.

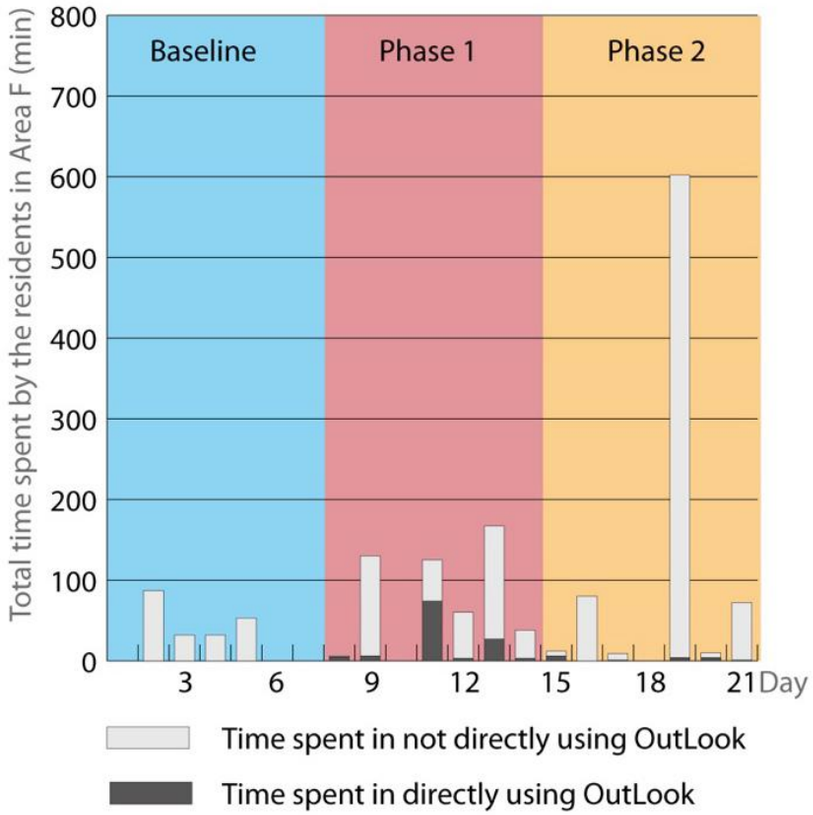


Figure 3-14 The total time spent by the residents in Area F through the observation period per day in the Baseline and the Intervention

	Baseline	Phase 1	Phase 2
Sum	172	526	785
Mean	24.57[a]	75.14[a]	112.14[a]
SD	34.58	65.79	218.43

Table 3-2 Sum represents the total time spent by the residents in Area F through the observation period in the whole week (min). Mean represents the average time spent on each day (min), and the letters indicate significant differences. SD represents standard deviation.

Hypothesis 3: The residents were expected to spend more time in social interaction in Area F.

The social interactions observed mainly included talking, listening to caregivers (including family, staff or volunteers), and sharing photos or postcards. To measure this, we added up the social time through the observation period every day in Area F (Figure 3-15). As we can see from Table 3-3, the average time spent in social interactions per day sharply went up by 83.7% (Phase 1) and 85.8% (Phase 2) after OutLook was installed. The increase in Phase 1 nearly reached significance ($p=0.08$), and there was no statistical significance between Baseline and Phase 2 ($p=0.29$) or Phase 1 and Phase 2 ($p=0.88$).

Figure 3-15 also demonstrates how much social time was triggered directly when the residents were using OutLook. As we can observe, only 17.43% and 4.27% of the residents' social time in the whole session of Phase 1 and Phase 2 was directly triggered by OutLook.

Therefore, similar to the results of hypothesis 2, although the residents spent a lot more time in social interactions, which preliminarily supported our hypothesis. However, a very small portion of the social interactions was directly triggered by OutLook, and as time passed, this proportion was getting less. We also had the assumption that they may talk about OutLook when they sat at the tables, but we did not record vocal data. This assumption needed to be confirmed in the interviews.

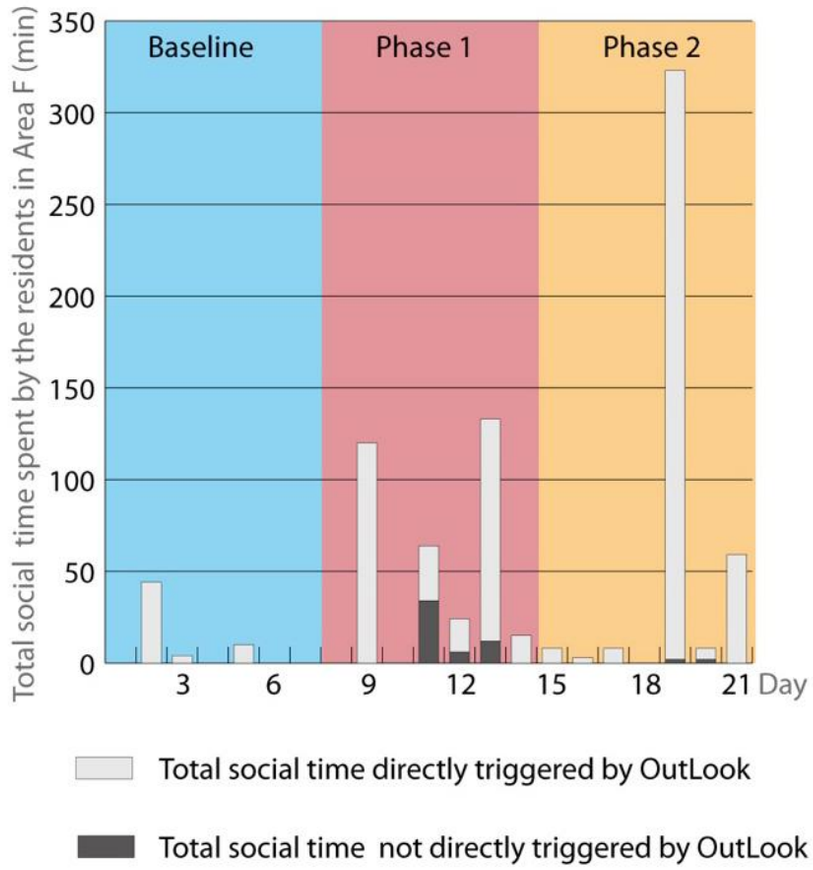


Figure 3-15 The total social time spent by the residents in Area F through the observation period per day in the Baseline and the Intervention

	Baseline	Phase 1	Phase 2
Sum	58	356	409
Mean	8.29[a]	50.86[a]	58.43[a]
SD	16.18	56.10	118.40

Table 3-3 Sum represents the total social time spent by the residents in Area F through the observation period in the whole week (min). Mean represents the average social time spent on each day (min), and the letters indicate significant differences. SD represents standard deviation.

- *Location analysis*

As mentioned above, we also recorded the locations of the residents. Figure 3-16 shows where the residents spent their time in each session from a holistic perspective (one dot means one minute). Generally, we can see that the residents tend to spend more time in this area in Intervention. But as time passed, the time spent in front of OutLook showed a declining trend. Within Phase 1 and Phase 2, the time spent in front of each display was at a similar level. Besides, we can clearly see that Table G5 was the most popular place they would like to stay in both the Baseline and the Intervention. According to the report, the main reason was that G5 was close to the canteen. It was difficult for the elderly to order something to drink if they sat far from the waiters in the canteen. Although G2 is also close, it was blocked by a wall. It perhaps could explain why G2 was one of the most unpopular choices for the residents.

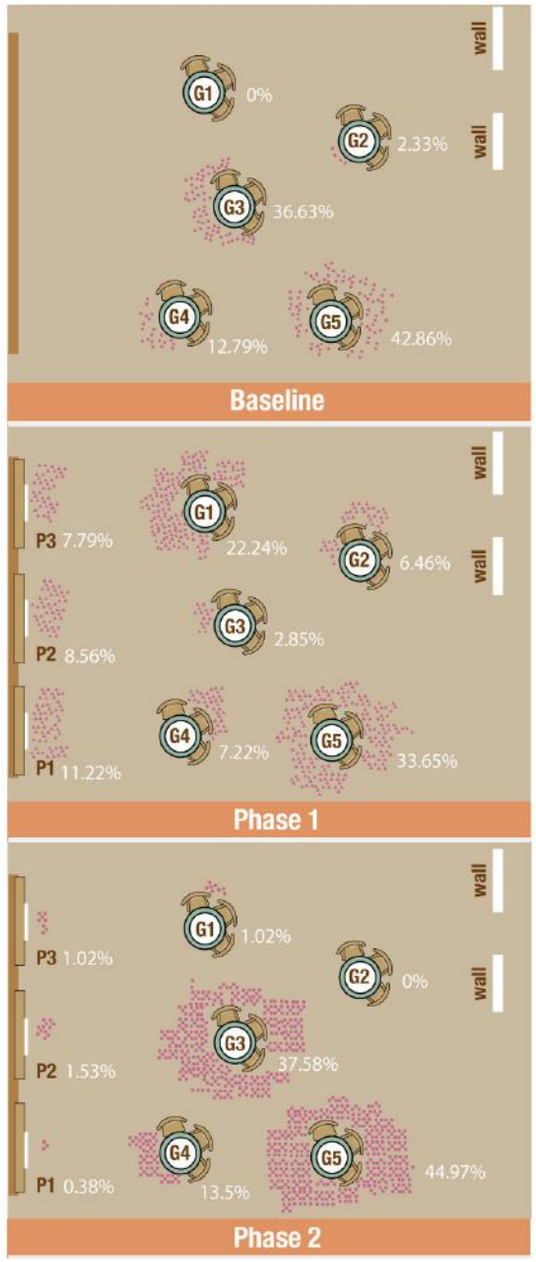


Figure 3-16 The distribution of the time spent by the residents in each spot of Area F in the whole session of the Baseline and the Intervention

- *Content analysis*

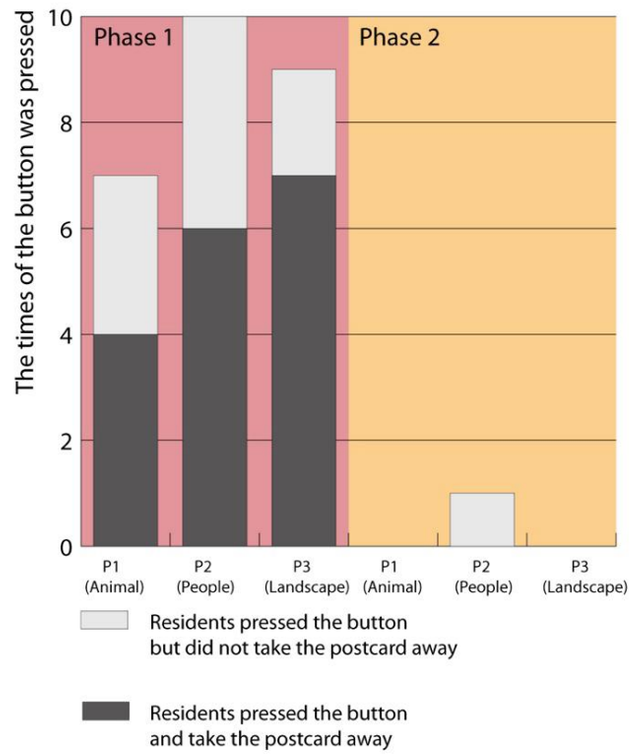


Figure 3-17 The times of the buttons pressed by residents in Phase 1 and Phase 2

We also wanted to explore whether the theme differences would affect residents' choice to print postcards. Figure 3-17 illustrates how many times the button of every display was pressed in Phase 1 and Phase 2. From the observation logs, we found that, even though some residents pressed the button out of curiosity when they passed the area, they did not have the patience to wait for the postcards to come out. From the chart, we can clearly see a radical decline in Phase 2, there was only one resident pressed the button once in the whole week, and he did not even wait for the postcard. Within Phase 1, there was not a significant difference between each theme. Generally, most residents would like to press the button of P2, but nearly half of them did not wait to take away the postcards. The postcards with pure landscape seemed more attractive to keep.

3.4.5 Result of Interview

Thirteen residents in total agreed to participate in the interview, ranging in age from 62 to 90 (Mean= 81). They were four males and nine females. Among the participants, eight residents (three males and five females) used OutLook according to the observation logs. As shown in Table 3-4, we classify them into Group 1. Two residents (two females) participated in the introduction activity but did not use it after that (Group 2). Three residents (one male and two females) had neither joined the introduction activity nor used OutLook, they were chosen randomly in the public spaces of the nursing home (Group 3). The participants were first asked their basic information including their job background and their usage of technology. According to their feedback, the main information sources were television and newspapers. Only one of them with an engineering background (S1, male, age 77) can use computers and smartphones.

Group	Participants	Joined Introduction	Directly Used
1	8	*Either*	*Yes*
2	2	*Yes*	*No*
3	3	*No*	*No*

Table 3-4 The participants of the interview were classified into three groups.

- *Usage and perception of OutLook*

To investigate how the participates used and understood OutLook, they were asked whether they had noticed the existence of OutLook. All the residents in Group 1 and Group 2 said yes while all the 3 residents in Group 3 said no even though they passed this area regularly every day. Among the 10 participants who noticed OutLook, 9 of them had joined the introduction activity, which was important for them to have a general understanding of how it works and motivated them to use it afterwards. One lady in Group 2 (S2, age 62) mainly paid attention to the displayed views but she couldn't describe the design intention although she had joined the introduction session. The other lady of Group 2 (S3, age 90) admitted that she didn't press the button because she was afraid to make mistakes. "*I don't start to use, all, all these devices.*" She said. The only participant who used OutLook

without attending the introduction was S1. He was attracted by the displays when passing by. He could also well explain the design concept without any instructions. However, for most of the participants in Group 1 and Group 2, it was difficult for them to retell the whole design concept even though they were clearly explained in the introduction activity. The most obvious feature of OutLook for them was printing postcards. Only three of them realized that the displayed photos were real-time scenes.

- *Overall use experience*

Before evaluating the residents' user experience, we explained the design concept again to make sure every participant could totally understand it. All participants in Group 1 expressed positive user experiences. One participant of Group 2 and all the 3 participants of Group 3 also showed a positive attitude to OutLook. One of them said: "*I find it fantastic to watch something happening. That, I think, I find that is very beautiful!*" The one female (S3) who refused to touch unfamiliar devices still showed very little interest. She was the oldest of all the interviewed participants (age 90). She had been leading a very inactive lifestyle in the nursing home. She stated: "*I just watch TV and also do nothing.*" "*I do not think too much when I sit downstairs. No, I am always upstairs in my own room.*" She came to the public spaces mainly for eating. Although she showed a great interest in one display with animals, she was afraid of any technical devices. She once had her son press the button but never did that when she was alone. We tried to design public displays in care environments to be friendly, simple and clear to the elderly, and most of the interviewed participants were very satisfied with the physical interfaces. They described OutLook as "paintings" and "photo frames", and most of them thought the buttons were very clear to them. However, they were also worried some other residents might be confused because their acceptance of technology varies greatly depending on their age and mental conditions. As for the digital interfaces, four participants of Group 1 strongly suggested it would be very helpful if some explanations could be added. They wanted to know when and where these photos were taken. Two participants of Group 3 also suggested, for those who did not attend the introduction activity, some booklets could also be provided nearby to introduce the design concept and guide them to use it. Seven of the eight participants in Group 1 had pressed the button, among which six participants

waited until the postcards came out. One female (S4, age 84) pressed the button three times when she finished her drink and went back to her room. But she left every time without waiting for the postcards. She thought the system was of great fun to watch but felt frustrated when no immediate feedback. Most of the seven participants who got the postcards chose to keep the postcards. Only one female (S5, age 79) sent it to her friend living abroad. She and another male (S6, age 65) had a hobby of collecting photos and postcards. They came to this area regularly to print postcards they liked. The other 5 participants usually used OutLook on their way to the canteen or back to their room. Most of them pressed the button once or twice in Phase 1, but in Phase 2, they mainly stood in front of it or sat in the distance to watch, which was consistent with our findings of the observation.

- *Feeling of connectedness*

One of the hypotheses that needs to be evaluated from the interviews was: OutLook would bring new feelings in the nursing home and make the residents feel more connected.

According to the interviews, 11 of the 13 participants agreed that OutLook had brought new feelings. The female (S3, Group 2) who refused to use OutLook and the male (S6, Group 1) who would like to use OutLook regularly to collect postcards stated that they felt nothing new. Two residents felt very fresh because they had never used such kind of things before. Most of the interviewed participants thought the new feelings came from the displayed views after they realized that they were real-time. They said: "*That brings a bit more life to the people, you know. Look, they cannot go out.*" "*I think it is nice, because there are many people who can't often go there.*"

As mentioned above, in our field trial, we were interested in residents' feeling of connectedness in three aspects: (1) the connection to the locations displayed on the screens; (2) to the people who shared the images and (3) to other residents. Generally, all the interviewed participants could feel a sense of connectedness to the shared locations in different extent. Five of them felt very connected because they could recognize the locations that recalled their related memories. One of them (S1) stated: "*We lived in North Eindhoven, so we went walking regularly. And uh, the university,*

yes, we have so often cycled through." They emphasized the importance of familiar locations. They felt like they could still do something when they were younger. Some participants who could not recognize the locations felt connected to the places when they were told that the images were real-time. Only two participants felt directly connected to the people who shared the views. Most of them said it was difficult to connect to someone they did not know, or they could not see. "*No, I only connect with people around me and the people in the (billiard) club.*", one participant said. Besides, the feedback from the interviews confirmed our result from the observation, which is, they did not spend much time on using OutLook every time and few social interactions took place when they were using it. Only two participants in Group 1 talked to other residents and shared postcards when they were using OutLook. Most social interactions took place after they left this area. Six of the eight participants in Group 1 said they talked to others after they used OutLook. Three of them talked to their family first and then to other residents. The other three participants talked to other residents directly. Two of the six residents liked it very much and recommended it to others. The topics are mainly focused on the intention of OutLook, how to use, printing postcards and the locations displayed. Most of them admitted that there was not much to talk about except they had postcards to share around or they were from the same community related to the locations on the screen. However, most of them would like to keep the postcards in their own rooms. The effect of OutLook to eliminate social barriers and trigger social interaction seemed difficult to sustain, especially when they left the area. Only one participant (S7, female, age 88) felt an obvious improvement in their social connectedness to other residents.

- *Other findings*

Besides these findings, most participants had the awareness that they should not sit in their rooms for too long, some of them kept complaining about the repetitive life in the nursing home, most of the time they had to find something to do themselves or they would be alone all day and do nothing, which was consistent with our findings of the preliminary study. They said: "*I find it is interesting, that's what all here and there are the same every day.*" OutLook had given some relief to this situation by displaying real-time images in an ambient way, which created awareness of presence for

the residents. Three participants suggested OutLook should be moved to other areas with more people, so that the residents would have more time to use and discuss. One participant also indicated that we could design many displays and distribute them in multiple spots to connect the residents in different areas. In addition, although we did not see a big difference between their preferences for the content of displays, but from the interviews, they expressed much more love of photos with nature and animals than people. It was interesting because according to our observation, postcards with people were printed the most times. We assumed that images with people would be easier to arouse residents' curiosity. There could also be other reasons such as the order we allocated each display or the image quality.

3.4.6 Key Design Factors and Lessons Learned

This collaborative study was the foundation of a series of my following studies aiming to propose guidelines and requirements for the development, design and research on IPDs for nursing home residents' social interaction. Although the system that we designed in this study consisted of two parts: ViewBricks and OutLook, my research focus was mainly on the OutLook inside the nursing home. My objectives were mainly to explore the social effects of IPDs in nursing homes and identify some initial design factors from our findings. This study preliminarily confirmed my assumption that IPDs in nursing homes could positively influence residents' social behaviors, which meant that I could dig deeper through more studies. As introduced in Chapter 2, numerous studies mentioned the design factors of IPDs and their related requirements. However, I believed that these factors and requirements needed to be further investigated if they would be applied in different contexts. In this section, I speculate on the key insights related to the design factors derived from this study, and also point out some lessons we have learned, which would be further verified in my following research:

- *The location of IPDs should follow most residents' daily habits*

As mentioned in Chapter 2, previous studies have already identified the importance of the context of IPDs, but the related requirements that fit nursing environments were still unknown. In this study, we acknowledged

the context of IPDs as a key design factor, especially the selection of the location. We chose to install OutLook in an unpopular area with a design ambition to make a difference. However, it turned out to be difficult to change the residents' daily routines. Even though the interview indicated that many of them do not like their repetitive life, they resist radical changes and stick to this habit for years. Unlike most traditional public displays mainly used by young people or children, the older adults are in a process of physical and mental deterioration, which means that their peripheral attention is gradually declining. In this study, a number of residents passed the area and ignored OutLook every day. Therefore, rather than introducing completely new things, design and research in the future should consider how to follow their habits and enhance their daily experience unobtrusively.

- *The displayed content should cater to the common interests of most residents*

Although it seemed to be a common sense that the displayed content was a key component of IPD systems, it rarely became a research topic. It was mainly because the content was highly determined by different design contexts and users. However, since my research focused on a specific environment and target group, content was identified as a key factor from our findings. In this study, our design was inspired by a phenomenon observed in a preliminary study that the residents liked to look out through windows. According to the results, OutLook could attract many residents to come and watch. But only those who loved collecting postcards came to press the buttons regularly. We believe interactive public displays in nursing homes should not just cater to the hobby of only one group. More open platforms should be designed to cover their common interests. Residents could also be empowered to be part of the content producers, which is essential for long-term use. However, the field trial indicated that residents' usage of the display could not accurately reflect their preferences. Therefore, we believe an extensive and independent user study on their media habits, interests or cultural background should be conducted before designing any IPD system in nursing homes.

- *The displayed content should keep updating explicitly*

Apart from the themes of the displayed content, we also found that the way of updating the content could also influence how the residents perceive and use the display. In this case, to minimize the interference of external factors, we only adjusted the camera angles and did not change the shared locations during the field trial, which resulted in a decline in the attractiveness of OutLook. Few residents pressed the button when they found the views were similar every day. Many residents expressed their wish to change locations. Besides, even though we tested OutLook in the university and most young people could notice the refreshment of the views, it seemed to be too implicit for the nursing home residents. The changes should be more explicit if we apply interactive public displays in nursing environments.

- *The interface should be friendly, explicit and inviting for the elderly*

In Chapter 2, we introduced display forms as one of the common design factors of IPDs. Given the acceptance and habits of older adults, we designed OutLook with a very typical form of vertical, flat and rectangular screens. Furthermore, the displays were decorated as a gallery to blend in with the environment. Such a physical interface was complimented by most of the participants from the interviews, which turned out to be an important factor for them to use. They expressed their love for the low-tech and decent appearance with photo frames and wooden material. The button was simple and clear to most of them, but it also created a feeling of a machine, which was not friendly to those with low acceptance of technology. As for the digital interfaces, using slideshows to attract residents was not as inviting as we expected, many participants did not even notice it. The digital interface designed for older users should be more explicit and inviting.

- *The interactions should be low-effort, immediately responsive and sustainable*

Among the three common interaction techniques introduced in Chapter 2 (Kurdyukova et al., 2012), we adopted bodily interaction and direct interaction in this case. Given the physical limitations of many residents, they just needed to stand in front of OutLook to trigger slideshows, which also

reduced the risk of social embarrassment. Pushing the buttons was also a low-effort and straightforward interaction for most residents. However, although OutLook was generally a success to attract the residents nearby to use, it failed to sustain the interactions. The typical scenario was found to be approaching, watching, pressing the button, and leaving. Many residents left without collecting their postcards due to the delayed response. The interview indicated that if the interaction between OutLook and residents were not sustainable, the triggered social interaction couldn't last long either. In addition, although the interactions required low effort, for those who did not have wheelchairs, most residents had to stand when using, which increased their physical burden. We also observed that a great portion of their social interactions took place when they were sitting at tables. Therefore, tabletop IPDs or IPDs with mobile devices on tables could be a potential direction to explore in future.

- *The deployment should include necessary introduction services*

In Chapter 2, we have mentioned that external factors such as certain events could influence the deployment of IPDs (Mäkelä et al., 2017). In this study, we found that necessary introductions and explanations played an important role for the residents to understand and motivate them to use independently. Most of the participants who used OutLook admitted that they got to understand it from the introduction activity. However, only 22 residents participated in this activity, although we sent 130 invitations. Furthermore, among those who joined the introduction session, many residents forgot most of our demonstrations and could not recall the whole idea afterwards. The main reason was that we only conducted this activity once and only lasted about 2 hours, which could not match many residents' schedules and daily routines. Besides, it usually took more time to attract the inactive residents to take part in new events than those active ones. Therefore, we suggest such activities are very necessary to introduce public technical applications in care environments and should cover more residents, especially those inactive ones. Specifically, first of all, the time and duration could be extended to match more residents' schedules. Printed introductions could be sent to their mailboxes to attract them to join and experience. Secondly, a semi-open pre-test session could be conducted for a week before the open field trial. Designers or caregivers could provide continuous assistance in this session. Thirdly, during the field trial, printed manuals with simple illustrations could also continuously guide them.

3.5 Summary of Takeaways

As mentioned above, my research purpose in this collaborative case study was to investigate the social potential of IPD systems in nursing homes and initially gain some key design factors. The result of the field trial indicated that OutLook successfully influenced nursing home residents' daily behaviors in public spaces and the user experience of the interviewed participants was reported to be positive, which confirmed the assumptions that such IPD systems could be designed and applied in public care environments to promote residents' social interaction. Key design factors were initially identified to be location, content, interface, interaction, and introduction services. Related guidelines were also summarized as lessons learned that need to be further validated in the following research. Besides the social impact and design factors, I also found two other aspects that were crucial to the success of IPDs for nursing home residents' social interaction: user engagement and design process.

In terms of user engagement, we found that the residents interacted with OutLook in different ways and levels from what we had expected. The design of OutLook was highly informed by previous interaction models such as the Three Zones Model (Streitz et al., 2003) and Interaction Phases Model (Heikkinen et al., 2011). However, it seemed that these established interaction models were not applicable to the public care environments. For example, due to the declining sensibility, acceptance of new technologies and stable daily routines, we found many residents didn't notice the ambient display of OutLook, although they frequently passed by. According to the participants who had directly used OutLook, they were mainly attracted by the displayed content or the physical appearance of OutLook instead of the subtle interaction (slideshows). Another example was that we found many residents preferred to sit at a distance and watch OutLook rather than actively stand in front of the display, especially in the later period of deployment. Therefore, it is worth further investigating to what extent nursing home residents would accept and engage with IPDs, which informs the RQ2 presented in Chapter 1.

In terms of the design process, as indicated in Chapter 1 and Chapter 2 (Section 2.7), we understood that the design of socio-technical systems for older people need to involve the end users. Therefore, in this case study of OutLook, we conducted informal observations and interviews in the contextual investigation, which proved to be very helpful to understand our target group and generate

suitable design concepts. We also conducted an informal group interview during Usability Test. However, the results of the field trial indicated that the involvement of the residents was not enough between the two sessions, which led to a gap between our design intentions and their perceptions. For example, many residents who had used OutLook did not realize the images were real-time even though some of them had participated in the introduction session. Therefore, we believe that residents should be involved throughout the design process and it is important to explore how to involve them in contributing the key design factors, resulting in the RQ4 presented in Chapter 1.

如切如磋，如琢如磨。

It is like cutting and filing the stone, Grinding and polishing the jade.

–《诗经》<Classic of Poetry> 800-700 BC

Chapter 4.
Deepen the Understanding of Context and Users

4.1 Introduction

As indicated by the implications of Chapter 3, the design and deployments of IPDs in nursing homes should follow most residents' daily habits, and the content should cater to their common interests. For most residents, moving into care homes means a radical restructuring of their living environments, daily routines and social relationships. Media habits are one of the few activity options that can remain consistent and maintain some sense of control (Hajjar, 2013), and media products are their main information sources. Researchers found that sharing media preferences, consumption patterns and practices could demonstrate common interests, which is helpful to trigger social interaction and develop friendships between aged adults (Chown, 1981; Flatt et al., 2012). Therefore, when designing IPD systems, it is very important to investigate residents' preferred content and topics to attract more users and trigger more social interaction. However, from the case study of OutLook, we also found that the usage of IPDs in the field trial was difficult to reveal residents' true preferences because of people's random behavior in public spaces. Furthermore, in contrast to younger generations, the media use of older people has received little attention (Claessens, 2013). The research focused on the media life of nursing home residents is even less available. Therefore, to deepen our understanding in this field and increase the success rate of the future systems that aim to attract nursing home residents with embedded media content, a context study needs to be conducted. In this Chapter, we describe a study investigating nursing home residents' media habits, preferences of genres and related social scenarios and barriers. Based on the results, three promising design strategies are derived to guide our following research and design. Part of this chapter has been published as a conference paper in *ChineseCHI '18* (ACM).

4.2 Common Media Products in Nursing Homes

Providing a wide variety of media products in nursing homes is a traditional strategy to continuously provide up-to-date information, entertain residents and create social opportunities. Generally, there are three types of media products: *print media*, *broadcast media* and *digital/multimedia* (McCracken and Gilbart, 1995).

Print media is a means of mass communication in the form of printed publications. Typical print media products are magazines, newspapers, books, etc. As one of the oldest forms of media, print media has long been a natural and accessible way for the older generations to receive and send information. It is also an ideal media form in public spaces because multiple people can use different print media products without disturbing each other (e.g., reading books in a library). However, because of the degradation of sight, mobility, memory and concentration, reading print media is getting much less attractive for the elderly. Many reports reveal a much lower consumption of print media by seniors (Vandebosch and Eggermont, 2002). In addition, the social effects of traditional print media are very limited. Reading and social interaction can hardly take place simultaneously, especially when reading is getting increasingly challenging for many older people.

Broadcast media mainly describes traditional media such as radio and television that typically reaches target audiences using the electromagnetic spectrum, although more recently, both of them have begun to be distributed by cable. Ever since the prevalence of television, watching TV has become the substitution of other media for many nursing home residents. Many studies report that older adults use television more than any other demographic group (Mundorf and Brownell, 1990). Besides, in spite of the booming of digital media, recent findings report television still ranks as the most prevalent and most time-consuming activity for seniors (Margot et al., 2012). Studies have shown that television can contribute to interpersonal communication by providing topics (Riggs, 1998). Some studies indicated that television viewing could reduce feelings of loneliness by offering company for older people (Vandebosch & Eggermont, 2002). However, many theories of media use among seniors portray high television consumption

as problematic due to its passive way of receiving information. In spite of the high consumption, older people were reported to enjoy TV much less than other stable leisure activities such as Bingo and musical programs (Depp et al., 2010). In nursing homes, spending large amounts of time on watching TV in private spaces can lead to problems such as lowered self-esteem, depression and low levels of interpersonal communication (Gerbner et al., 1980, 1986). Some nursing homes also try to continuously play TV programs in public spaces, but it is difficult to balance individual choice and administrative control (Hajjar, 2013).

In recent decades, *digital media* such as music, photos and videos, with their rich means to display and trigger interactions, has been widely used in public spaces to connect people in a certain area. However, given older adults' relatively low acceptance and ability to use digital media, they have long been playing a minor role in research and design to encourage computer-mediated social interaction in public spaces. As mentioned in Chapter 2 (Section 2.3.2), although some studies have explored integrating interactive digital media technology into public care environments, these applications were mainly controlled by caregivers and can hardly blend in with residents' daily life.

4.3 Context and User Study

4.3.1 Method

From the observations and interviews in the study of OutLook, we found that although a television was installed in the public space within the nursing home, it was rarely used. Many residents spent most of their time watching television in their rooms. Besides, very few of them were proficient in using digital devices such as computers, tablets and smartphones. Print media (shared and private) was still the primary media form that they used in public spaces of the nursing home. These findings were very consistent with previous studies mentioned above. Given this specific research context, in this chapter, we mainly investigate residents' habits and preferences of using print media products. This context study focused on the following questions:

1. *How do residents use different print media products in nursing homes?*

2. *Which genres do they commonly like?*

3. *Which genres do they usually discuss with others?*

4. *Under which circumstances would social interactions occur when they use print media products, and are there any related social barriers?*

For answering these questions, a qualitative approach through semi-structured interviews and card sorting activities was chosen.

4.3.2 Setup and Participants

This study was conducted in two nursing homes in Eindhoven, the Netherlands. Both of them are equipped with private apartments and multiple public spaces. The public spaces consist of one primary multi-functional space and several secondary spaces. The primary space is usually where residents eat, drink, socialize with each other and participate in regular activities. The secondary spaces are designed with specific purposes such as

reading spaces, game rooms and meeting rooms for small groups. Twenty-one residents participated in this study, ranging in age from 66 to 95 (M=82). Ten residents are from Nursing Home A (3 males, 7 females). Eleven residents are from Nursing Home B (4 males, 7 females). Since both of the two nursing homes have a closed area for residents with dementia, all of our participants had lucid minds and were chosen randomly in the open spaces within each nursing home. To overcome the language barrier, I invited a local interpreter as the research assistant in this study.

4.3.3 Procedure

To answer the first three questions mentioned above, we prepared a list of common print media products and genres for the participants to choose from. Since many residents have difficulties in browsing intensive information within a short time, we designed a series of cards, and each represents the kind of media products and genres (Figure 4-1). Each card was designed in a combination of an image and Dutch texts for the residents to have a clear understanding quickly. The list of common media products is based on the classification from Kipphan's (2008) book 'Handbook of Print Media'. We added some items based on our observations in the field trial of OutLook to fit this context. The final list consisted of 10 print media products in care environments (Figure 4-1), including books, billboards, brochures, flyers, magazines, menus, newspapers, posters, photos or albums, and postcards or letters. Our list of genres is based on the classification for books from the online shopping website bol.com and it was also revised for our context. The list is composed of 29 genres (Figure 4-1), including activities in the nursing home, architecture, advertisement, art, biography, culture, comics, cook, family, fantasy, health and psychology, hobby, house, history, kids, life in the nursing home, management, news, nature, photography, politics, romance, religion, sport, study, travel, thriller, TV programs and young adult. In addition, in order to facilitate the participants to answer the fourth question, we took photos of some typical public locations in the nursing homes and also printed them as cards to help the elderly recall and describe related social scenarios (Figure 4-1). The three kinds of cards were printed in different colors to make it easier for the experimenter and participants to distinguish the card categories.

Card Type	Encompass	Example
Media Products	(1) books, (2) billboards, (3) brochures, (4) flyers, (5) magazines, (6) menus, (7) newspapers, (8) posters, (9) photos or albums, (10) postcards or letters	 Brochure
Media Genres	(1) activities in the nursing home, (2) architecture, (3)advertisement, (4) art, (5) biography, (6) culture, (7) comics, (8) cook, (9) family, (10) fantasy, (11) health and psychology, (12) hobby, (13) house, (14) history, (15) kids, (16) life in the nursing home, (17) management, (18) news, (19) nature, (20) photography, (21) politics, (22) romance, (23) religion, (24) sport, (25) study, (26) travel, (27) thriller, (28) TV programs, (29) young adult.	 Architectuur
Public Locations	Typical public locations were selected and recorded as photos, including hallway, mini library, canteen, activitiy rooms, etc. The places in the photo were numbered as shown in the example.	 01

Figure 4-1 We designed three types of cards in different colors to represent media products, genres and typical public locations

In the beginning of each interview, participants were given a brief explanation of the objectives of the study. After asking their basic information (name, age, room number, education background, employment history) in the first part of the interview, we asked them: "What kinds of print media do you usually use?" We then showed them the 'print media' cards one by one and told them they could choose as many as they liked. Then, among the cards they had chosen, the participants were told to choose which of them they used in their apartments and which in public spaces or both. Similarly, we then showed them the 'genre' cards one by one and let them choose as many as they like (Figure 4-2). Among the 'genre' cards they prefer, they were told to choose which of them they would like to talk about with other residents. As older people belong to a vulnerable group, and may experience some difficulties in recalling and expressing, we used the 'location' cards to lead them to talk about the current social scenarios related to print media and barriers they encountered instead of directly asking them to describe.

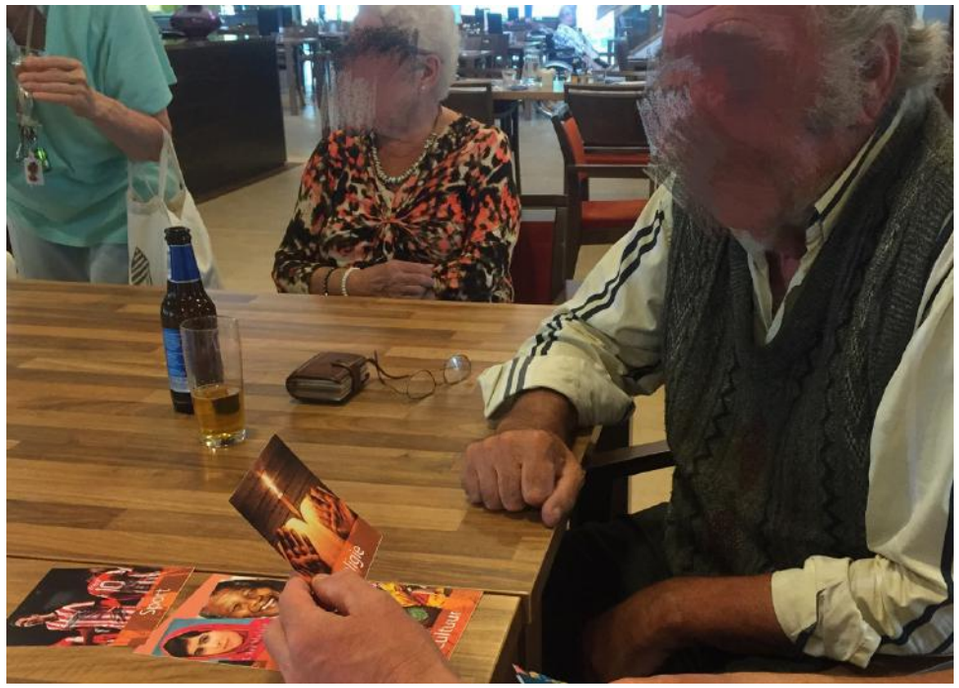


Figure 4-2 The resident was browsing and selecting cards

4.3.4 Data Collection and Analysis

The first part of our interview elicited demographic information of each participant, such as age, education background, employment history and prior experience with technology. The data were then analyzed using descriptive statistics. The selection of cards was recorded in two categories: (1) their use of print media; (2) their preference of genres. The first category was divided into three parts: (a) the print media they usually use in general; (b) the print media usually used in their private apartments; (c) the print media usually used in public spaces. The second category was divided into two parts: (a) their personal preference; (b) their social preference of genres with other residents. The interview sessions on their current social scenarios related to print media and barriers they encountered were audio-recorded and were later transcribed and manually analyzed in NVIVO using the thematic analysis technique (Braun & Clarke, 2012).

4.3.5 Results and Discussion

- *Demography*

Gender	Sum	Age				Education	
		60-69	70-79	80-89	over 90	Elementary level	College level
Male	7	0	1	4	2	4	3
Female	14	1	2	10	1	13	1

Table 4-1 Participants' age distribution and their level of education

As shown in Table 4-1, among all twenty-one participants, one female was from the age group 60-69. Two females and one male were from the 70-79 age. Our participants were mainly between 80-89 years old, and they were ten women and four men. Three participants were above 90, two men and one woman. All of them could read and write. College education was their highest education level. Only four participants received a college education; three of them were men. Seventeen participants received elementary school education; two females did not finish their elementary education to help housework in their family. Most of our participants were born in the 1930s and the 1940s. This is a generation that had experienced the Second World War when men had an absolute priority in higher education. Many schools were established to teach women about housework.

Gender	Sum	Employment		Information Source		
		Non-Professional	Professional	TV and print media	Smartphone	PC
Male	7	2	5	7	0	0
Female	14	11	3	14	2	0

Table 4-2 Participants' past career and their information sources

In terms of employment history (Table 4-2), thirteen participants (2 males, 11 females) had non-professional careers such as housewife, tailor, factory worker, waitress and cleaner. Eight of them (5 males, 3 females) had

professional careers such as engineer, administrator, civil servant, teacher and secretary. Television and print media products are their main information sources. Only two females could simply use smartphones. They were taught by their family and had difficulties in searching information from the Internet. None of them could use computers.

- *Use of Print Media Products*

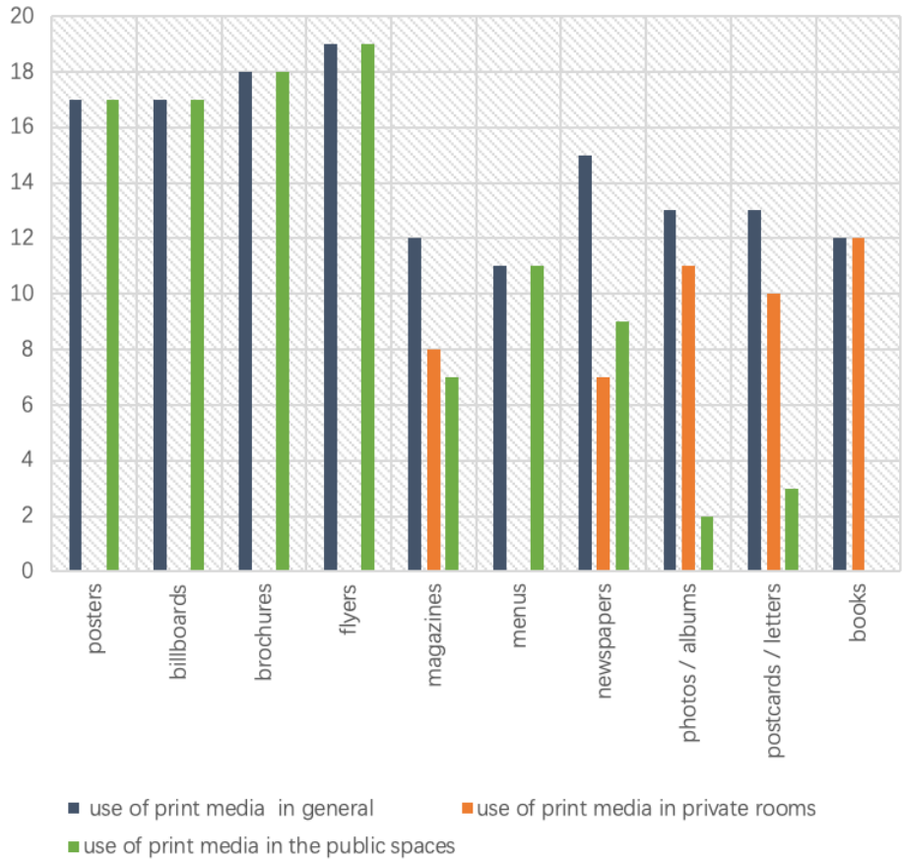


Figure 4-3 Participants' use of print media in general, in private and in public spaces

The blue bars in Figure 4-3 describe the print media products usually used by residents in general situations (including public and private spaces). As shown in the figure, posters, billboards, brochures and flyers were the most used

in their daily life. From the interviews, we knew these products were mainly provided and maintained by caregivers. Residents highly relied on them to get access to information about upcoming activities and care services in nursing homes. Although they also had digital screens displaying such information, many residents still insisted on keeping the printed version because digital content kept changing and would not wait for them to fully get the information. Out of these 4 print media products, flyers and brochures were used more than the other two because they were put on the tables where it was easier for the residents to get access. The following popular product was the newspaper. Even though television was their main news source, 15 of them still had a habit of reading newspapers. Magazines, menus, photos, albums, postcards, letters, and books were a little less popular in general, and there were no significant differences between them.

The red and green bars summarize the participants' use in their own apartments and public spaces, respectively. They indicate that all the four most popular print media products were only used in public spaces. As for newspapers, 8 participants usually read it in public spaces because the latest newspaper was always put on public tables. Drinking coffee, reading newspapers and waiting for possible social contacts had become an important part of their typical daily routines. Six participants preferred to read in their own rooms mainly because it is much more comfortable and quieter. They usually subscribed to newspapers themselves and sometimes brought them to public spaces after they finished reading. One participant had no special preference of where to read newspapers. For similar reasons, although there were reading tables and mini libraries in both nursing homes, none of the participants read books in these areas. Twelve residents preferred to read in their apartments because they need more sustained attention for books than newspapers. Regarding magazines, as shown in Figure 4-3, there was no significant difference between locations. Five participants usually read in their rooms, four often read in public spaces and three did not have preference. It depended on their interests and situations. As we can see from Figure 4-3, most participants chose to use photos / albums (84.6%) and postcards / letters (76.9%) in their rooms. Most of them were only interested in photos and postcards related to their own life and always kept them in their rooms except special occasions. Only one woman put her albums in her trolley and took them out every day for sharing.

- *Preferences of Genres*

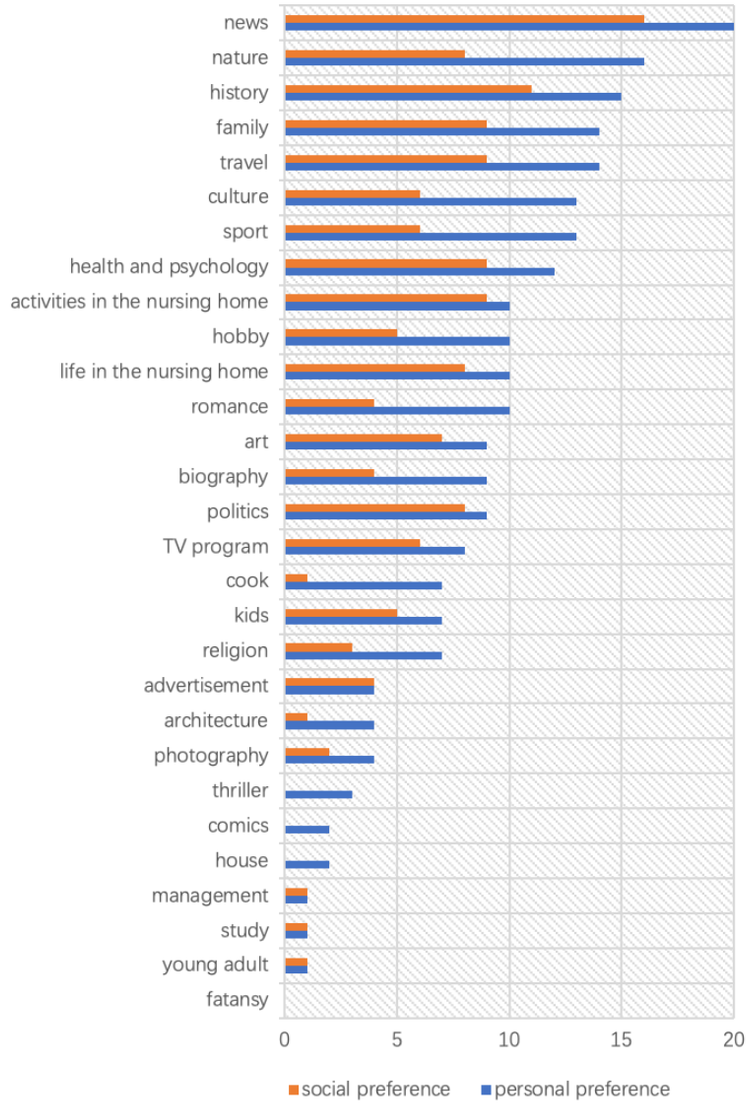


Figure 4-4 Participants' preference of genres

Figure 4-4 summarizes participants' personal interests in genres of print media and their social preferences of these genres. News was not only their favorite genre but also the most popular topic they would like to talk about with other residents. As reflected from the interviews, exchanging opinions on recent news helped them to engage in daily social conversations. Most of them felt social connection to talk about local news

or news from their neighborhood much more than national and international news. Such news could also include genres such as politics, activities in the nursing home and life in the nursing home, which would resonate with other residents. They mainly got such news from newspapers, posters, flyers, brochures, billboards and magazines published by their care organization. Although "nature" was their second favorite genre, it was not that popular when it became a topic for discussion. They found it was easy to start a conversation about nature such as weather and outside sceneries, but such communication was hard to sustain and was quickly changed to other topics. In addition, compared to texts and static images about nature, they prefer dynamic content from TV programs. History was another important subject. Fifteen participants liked print media products related to history and 11of them would like to talk about it with others. To be specific, the history related to their past life may attract them much more than the general history. This topic may more or less overlap with other genres such as family and travel, which they also would like to talk about. When they talked about their travel experience, it could also be related to local culture. These genres usually came from photos, albums, postcards, letters, and magazines. Besides, they indicated that although topics such as news, activities in nursing home and life in nursing home were frequently mentioned in their conversation, topics about history, family and travel experience could trigger more meaningful conversations because they were more personal. Health and psychology have always been one of the most concerns for the elderly. They paid attention to health-related content and shared it with others. However, many participants admitted such conversations were mostly focused on their own health complaints and few people were really interested in it. Romance, fantasy, biography, and thriller were typical genres of books. The majority of our participants treated reading books as a self-entertainment activity. They rarely share with others except on special occasions such as reading clubs. Genres like sports, art, hobby, photography, architecture and religion depended highly on personal interests and beliefs. Other unpopular genres mostly related to self-development such as study and management, which could also be explained by many studies on aging like Socioemotional Selectivity Theory (Löckenhoff and Carstensen, 2004). It argues that when people are getting old, their social focus would gradually shift from future-oriented and knowledge-related goals to present-oriented and emotion-elated goals.

- *Related Social Scenarios*

Based on the participants' feedback, there were mainly two kinds of social scenarios related to the usage of print media products:

(1) The majority of the social scenarios described by the participants were caused by the ***transfer or exchange of print media products***. Such experiences usually took place with their family members. "*My daughter brings books to me, she reads the books first and recommends them to me. Later we talk about the books when she comes.*" P2 (female, Nursing Home A) said. Such scenarios were also mentioned by P15 (male) and P16 (female) from Nursing Home B: "*I get magazines from my children, because we have special interests.*" For the residents who had reading problems, sometimes their families would read for them, which they thought was a good way to enhance their emotional bonding. But it rarely took place more than once a week because their family members were often busy. Sometimes, they also borrowed or loaned print media with other residents. P10 (male, Nursing Home A) said: "*I had a book about Philips and Eindhoven. When there are people new to the nursing home, I lent it to others to understand Philips and introduce the special history of Eindhoven.*" However, he also admitted that they rarely talked about it afterwards and even less often read together. Two ladies from Nursing Home B (P17 and P18) had a habit of exchanging magazines, but mainly for the puzzle riddles.

(2) Another typical social scenario was related to ***personal sharing***. P5 (female, Nursing Home A) and P14 (female, Nursing Home B) described a similar social experience. They liked to take their personal print media products (e.g., postcards, albums) to public spaces for sharing. "*I have shown my photobook to many people living here. Once I also performed how to milk (cows) to them.*" P14 said. However, three participants (P7, P20, P21) didn't like sharing personal things due to privacy. "*If I receive postcards, that is personal for me. Nobody would do anything with it. Photos are also private things. My whole life is in photobooks. I prefer to read in my room.*" P20 (male, Nursing Home B) said.

- *Related Social Barriers*

Overall, five kinds of social barriers related to print media products were mentioned by the participants:

(1) The first barrier was mainly due to their ***physical or mental degradations***. Some participants gave up reading because of various sensory impairments "*My concentration is very bad now and hard to read any book.*" P6 (female, Nursing Home A) said. Their physical problems also brought more challenges to their social interaction. P1 (male, Nursing Home A) complained: "*I am a little deaf, which makes communication really hard.*"

(2) The second barrier mentioned was the ***lack of ideal media products for social interaction*** in the public nursing environment. As mentioned above, all the participants agreed that traditional television was not appropriate to be applied in their public spaces, and very few of them could use common digital devices such as smartphones or tablets. Regarding print media, a lot of participants held the opinion that social interaction and using print media were contradictory behaviors in public spaces based on their past experience. "*When you are reading something in the restaurant, you isolate yourself.*" P20 said.

(3) The third barrier that they complained about was the ***difficulties in finding the right person to talk to***. Unlike the close relationships with family members, most relationships between residents were no further than acquaintances. Although they met and communicated almost every day, they lacked the opportunities and abilities to express their own interests and find people with the same ones. P5 (female, Nursing Home A) liked to read art books. She mentioned: "*I like to talk about art but most people here are not interested in art. I wish to share, but I think it is impossible to do it here.*" Additionally, many participants claimed that they only talked to others who were at the same mental or educational levels. "*It is difficult to talk to someone that cannot completely understand what you are talking about, or it would become a different story.*" P12 (male, Nursing Home B) said.

(4) The fourth barrier was the ***lack of meaningful topics***. For the residents who frequently went to the public space, since they basically meet the same

group of people, it was very challenging for them to find something to talk about. Two participants (P2 and P19) directly admitted that they couldn't come up with new specific topics to share with others every day. Nine participants complained that their current topics were very limited and superficial. "*They only talk about gossips and complaints*." P8 (female, Nursing Home A) said. P11 (female, Nursing Home B) expressed the same opinion: "*Nothing to talk about here. It is difficult to share things here. You cannot talk about real subjects, just general things, no further talking*."

(5) The last barrier was mainly about the ***overall social atmosphere in nursing homes***. Six participants mentioned that many residents were very passive in social interaction. P2 said: "*Some people here are solitary and shy to talk. They don't seek social contact actively.*" Apart from their personalities, a more important reason, according to her, was the difficulties in joining the stable social groups. "*Before Eindhoven became a whole city, it was made of many villages. For the elderly, it is very important. There are many small groups formed based on the communities that they came from, which makes it hard for others to join*." She said. P8 also pointed out: "*When you are old, it is hard to meet new friends*." Six participants mentioned that they have tried to build contact with other residents, but they rarely receive positive feedback. Thus, most of them wouldn't try anymore. P6 said: "*I read books. Sometimes I talk to people if they are nice, but most of time, everyone is not nice*." P19 (female, Nursing Home B) also mentioned: "*I have wide interests, but the responses are disappointing*." Therefore, some participants said that they would rather be alone than be denied by others. P7 (male, Nursing Home A) said: "*I have no connections with other people living here, and I don't feel the need to connect to them*." In spite of the poor social atmosphere, P19 forced herself to go to the public spaces. "*You cannot always have people to talk to. Sometimes you just come to sit and look around, or if you don't do this, you are easy to get isolated, always alone*." She said.

4.4 Summary of Takeaways

In this Chapter, we present a context and user study that investigated nursing home residents' media habits, preferences of genres and related social scenarios and barriers. Since nursing home residents' consumption of television has been investigated by numerous studies (Hajjar, 2013; Depp et al., 2010), and digital media products were rarely used by the residents in our context, this study mainly focused on print media products. The result of residents' media habits not only revealed some typical print media products commonly used, but also separately demonstrated their usage in residents' rooms and public spaces, which is very important to guide the design for different nursing environments but often overlooked by previous studies. The result of residents' preferences of genres showed not only their personal interests but also some popular subjects for discussion, which can inform the design of content-based systems aiming to attract individual residents or promote their social interaction. In addition, we summarized two kinds of social scenarios and five kinds of social barriers related to print media, which can contribute to a deeper understanding of nursing home residents' social lives and demands.

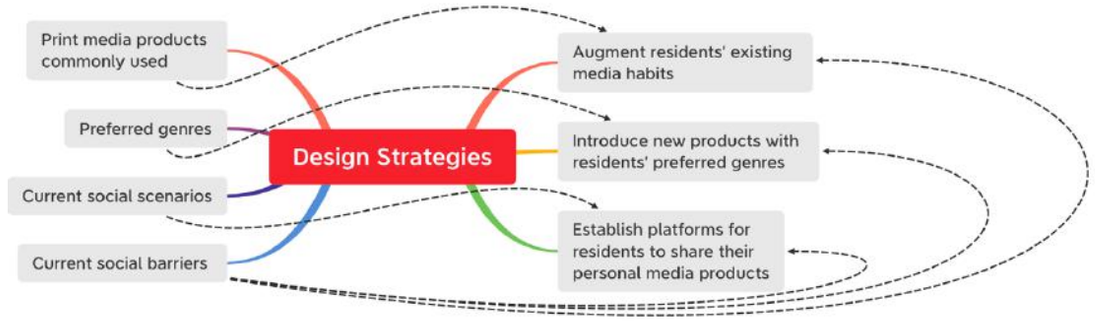


Figure 4-5 Design Strategies are generated based on the idea of enhancing their current habits, preferences, and positive social experience, and overcoming related barriers.

4.5 Design Strategies

This context and user study can also inform my following design of IPD systems by generating overall design strategies. As shown in Figure 4-5, the core idea is to enhance residents' current habits, preferences, or positive social experiences and reduce the related social barriers. Based on this idea, we initially conclude three design strategies, and they are explained in detail as follows:

- *Augment residents' experience of existing media habits*

The results of this study showed that the participants primarily used print media products in public spaces of the nursing homes, which further confirmed our findings in Chapter 3. Reading in public areas has been an important daily routine for many residents to motivate them to leave their rooms. However, there were a number of residents stopped doing this due to their physical deteriorations. The dynamic surroundings in public areas also make it more challenging to focus on reading. Furthermore, as indicated by the participants, reading has been seen as an activity of isolation rather than social interaction. Given this, IPD applications can be designed to follow nursing home residents' current or previous media habits. Their familiar media products in public spaces (e.g., brochures, flyers, magazines, newspapers) can be used as content sources or interfaces to keep attracting residents to naturally use. The proper forms of display can be applied to reduce residents' physical barriers. Moreover, the digital content can be used to match these media products with their preferred genres (e.g., activities in the nursing home, news) to trigger conversations. Various interactive features can also be integrated to enhance their social experience. For example, musical activities held in nursing homes can be digitally recorded by caregivers and digitally embedded in physical brochures, flyers or magazines. Residents who have not joined could also enjoy it afterwards. Besides, for those who love music, they can also review the activities and exchange their feelings whenever they like. Physical newspapers can also be connected to the Internet to provide real-time digital news, which can not only help residents who have difficulties in reading small fonts, but also provide them with various up-to-date topics.

- *Introduce new media products/systems with residents' preferred genres*

Self-interest is a central property of many social studies such as social exchange theory (Roloff, 1981). Roloff (1981) claimed that self-interest would act as the guiding force of interpersonal relationships for the advancement of both parties' self-interest when it is recognized. Normally, people's interests could be reflected more or less by what they read or use. But for older people, traditional print media products cannot help much to disclose their' self-interest in the public care environment. The result of this study reveals that many genres or themes that residents liked (e.g., nature, history, travel, culture) cannot be sufficiently provided by their existing media products. Even though some of them were provided, the content was static and non-interactive. Therefore, as the second design strategy, we believe IPD systems can be introduced with new interfaces to better cater to residents' preferences and facilitate their social interaction. For example, places where the participants had been frequently mentioned when they explained their preferred genres, such as history, family, and travel. Usually, nothing could be better than a map to convey location-based information, but they rarely exist in the public places of nursing homes. Even if they can be provided, using traditional maps is difficult for most older people due to the tiny letters and complex information. Therefore, IPD systems can be installed in nursing homes with special maps related to residents' life experiences. The map can be connected to digital location-based information from the Internet, such as Google Street View or streaming media uploaded by younger people. By using this, residents might be motivated to explore together and share their own related stories.

- *Establish platforms for residents to share their personal media products*

As was reflected in this study, there were many media products mainly used in residents' private rooms, such as photos, albums, postcards, letters, books, or even television. The genres of these media products were often about residents' emotions and personal experiences, such as family, history, travel, and interests (art, sports, etc.). Although some content might be related to their privacy, the result showed that many residents had the motivation to

share these personal belongings. However, our participants indicated that they lacked the opportunities to do this in public spaces. Therefore, we believe that residents' mutual understanding and communication would be enhanced if IPD platforms could be established to facilitate residents to share their personal media products with their preferred content. For example, postcards sent by residents' families and friends were used to be kept in their drawers and rarely shared in public spaces. But if they could watch their family videos embedded in these postcards somewhere in the public spaces, we suppose it would be a motivation for them to use postcards in public spaces. Furthermore, it may also be helpful to enhance their family bonding.

Since the three design strategies aim to change residents' behavior in different degrees, the first strategy could be the most acceptable for the residents because it conforms to their current daily habits with the lowest learning costs, which makes the first strategy to be an ideal solution to start with and cultivate user habits. The related genres such as news and activities in nursing homes are common topics to every resident and would be effective to improve their interests and frequency of social interaction. Although the second and the third strategies are more challenging, and their related topics are more personal, we suppose that, by sharing self-interests, relationships and past experiences, it would be helpful to improve their quality of interaction and feelings of social connectedness. Therefore, the selection of the design strategies should highly consider residents' current media habits, acceptance and capacity of using the introduced technology, and the social impact aimed to achieve.

Chapter 5.
Design and Development of R2S

5.1 Introduction

To validate the key factors from the case study of OutLook (Chapter 3) and further investigate the social impact of IPDs on nursing home residents, we continued our research with a follow-up case study. Guided by the design strategies derived from our context study in Chapter 4 (4.4), augmenting residents' experience of existing media habits via IPD systems is taken as a promising direction to start with. Our lessons learned from the case study of OutLook also indicated that following residents' daily routines would lead to higher acceptance and adoption of the introduced technologies. The result of our context study in Chapter 4 showed that newspapers were frequently used by many residents in public areas, and the news was not only one of their favorite genres but also among the most popular topics for discussion. However, their interest in reading was restricted by their physical degradations and the social opportunities were limited by the conventional printed media form. Therefore, we decided to design an IPD system aimed at enhancing residents' daily experience of reading newspapers by reducing their physical and social barriers. In this Chapter, we describe our design process consisting of two stages: ideation and refinement. The lessons learned from the case of OutLook led us to involve the residents throughout the process more. Participatory and collaborative design methods were adopted. At the end of this chapter, we present the concept design and prototype of the generated IPD system: Reading-to-Sharing (R2S). Part of this chapter has been published as conference papers in *TVX 2019*, *ADIM 2019* and *DeSForM 2019*.

5.2 Ideation

Since we started with the first design strategy to digitally augment nursing home residents' daily experience of reading newspapers via an IPD system, the next step was to develop a design concept. In this section, we demonstrate our exploration of involving nursing home residents in the ideation phase. The main purpose of this phase was to initially investigate residents' acceptance and perception of such an IPD system, collect their design requirements and generate an IPD design concept.

5.2.1 Method

The method was adapted from the concept development phase of a participatory design model called Usability, Safety, Attractiveness, Participatory (USAP) design model developed by Demirbilek and Demirkan (2004). This model is one of the few participatory design models specially developed to describe how to involve older people in the design process. It aims to improve older adults' quality of life by promoting independence and social wellbeing. Although this model generally fits our context, it mainly focuses on designing traditional housing and architectural products for general older adults. Therefore, we adjusted the method in the concept development phase to meet our needs of involving nursing home residents to design new technologies.

In the original method, design sessions are organized with small groups of older people. The typical techniques adopted are scenario building, brainstorming, idea writing and sketching, unstructured interviews and asking pre-set questions (Demirbilek and Demirkan, 2004). In this phase, the role of designers is mainly acting as facilitators or moderators to encourage older participants to make proposals. The data collected from the ideation, including the answers to the pre-set questions, proposals, requirements and ideas, are analyzed with a USAP deployment matrix to find the relationships between user demands and system specifications.

To test this method, we organized a pilot session with a group of 4 nursing home residents. We found that it was difficult to keep all the participants

actively engaging in the activity, mainly due to their different levels of physical and mental conditions. The more capable residents could easily lead most conversations and influence the answers of others. Besides, the inactive residents could hardly hold their concentration when the active ones were talking. Many previous studies tended to selectively involve "healthier" and "smarter" older people to contribute ideas, but in order to design a public system for general residents, we believe the demands of the vulnerable group should not be overlooked. Besides, we found that all the participants found it very challenging to directly propose design ideas because the concept was still vague, and they had never seen such systems before. They were also resistant to sketch with various excuses, such as their poor health and limited knowledge about technologies. Answering pre-set questions was much more acceptable for them to keep engaging in this activity.

Based on the feedback from the pilot session, we adapted the methods and techniques used in the concept development phase of the original model. As shown in Figure 5-1, the adapted method consisted of three stages. In the first stage, residents were mainly involved individually. Rather than directly encouraging the participants to propose ideas, we mainly captured their design requirements by pre-set or semi-structured questions and scenario building techniques (Suri & Marsh, 2000). The participants' feedback was recorded, transcribed and manually analyzed with the thematic analysis techniques (Braun & Clarke, 2012). In the second stage, designers analyze the design assumption based on their knowledge or relevant sources to initially identify potential technical features (Demirbilek and Demirkan, 2004). The last stage is the process of representation. In this stage, designers interpret the elderly users' real desires and match them with their professional knowledges. The USAP deployment matrix (see Figure 5-3 for an example) is employed to find the relationships between residents' demands and system specifications (Figure 5-1). Finally, design output including preliminary concepts and prototypes could be formed by analyzing the priorities of user requirements and technical features.

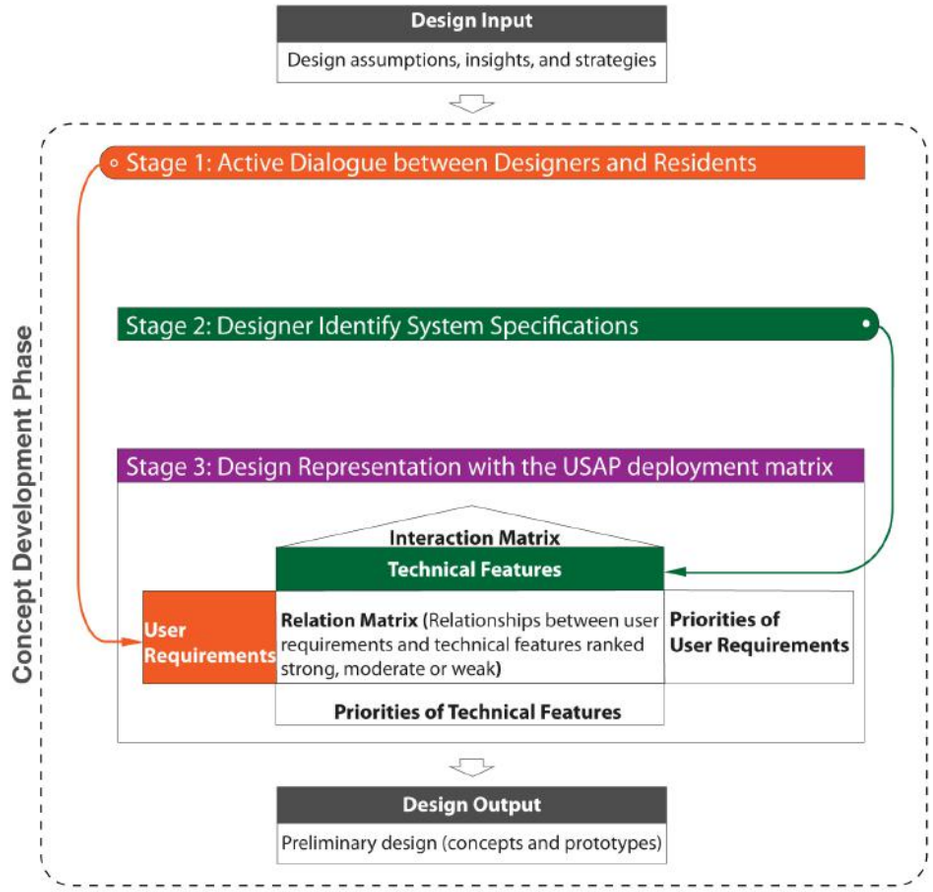


Figure 5-1 The three stages of the adapted concept development phase (ideation)

5.2.2 Setup and Participants

The ideation sessions were carried out in a nursing home in Eindhoven. This nursing home belongs to *Vitalis WoonZorg Groep*, a national care organization that has set up many similar nursing homes distributed over this city. We firstly acquired permission from the managers to conduct the study. The participants' oral consent was recorded before each interview due to their reading or writing difficulties. Eight residents took part in this study, three males and five females, between 69 and 92 years old. They were randomly invited to the public areas during our eight visits. They all have normal cognitive functions because the care home had a separate area for the residents with dementia.

5.2.3 Procedure

Each session was conducted with one participant and lasted about 1 hour. It started with a quick explanation to inform the participants that we were exploring a new experience of reading newspapers by integrating print and digital media in public space. They were encouraged to express their opinions and envision a future design together with the designers.

To understand the residents' current use of newspapers and related demands, we conducted semi-structured interviews. They were guided by the following questions: 1. *Where do you usually get news?* 2. *How often or in which situations do you read shared newspapers in public spaces?* 3. *Which sections do you prefer to read?* To facilitate the interviews, we provided them with a local newspaper that was available in the public areas every day.

To investigate their acceptance and perceptions of the IPD system to be designed, we followed the process of scenario building (Suri & Marsh, 2000). We randomly selected a piece of news from the newspaper and prepared related digital information, including a video, an audio clip, six images, news in digital texts and people's reactions from social media. These were saved on a 10.5-inch tablet. We let the participants experience a scenario where they were sitting in the cafe and getting news information from three different media forms that we prepared: newspaper, newspaper with digital

information from the tablet and only digital information from the tablet (Figure 5-2). After experiencing each scenario, they were asked to fill in a simple questionnaire to assess their perceived attractiveness (five scales from very unattractive to very attractive) and the possibility to trigger social interaction (five scales from very unlikely to very likely). In the end, they were encouraged to explain the reasons and select their preferred digital information.

Figure 5-2 A participant experiencing different simulated scenarios

5.2.4 Participants' Feedback

Participant	Gender	Age	Length of Residence	News Source
P1	F	82	4.5	TV, smartphones, newspapers
P2	M	73	3	TV, smartphones, newspapers
P3	M	69	2	TV, newspapers
P4	M	86	1	TV
P5	F	82	8.5	TV, newspapers
P6	F	92	11	TV
P7	F	71	2	TV
P8	F	80	2	TV, newspapers

Table 5-1 The participants' basic information and news sources

- *News Sources*

As is shown in Table 5-1, all the participants mainly relied on television for news. P4 and P6 could not read newspapers due to visual impairments. P7 had little interest in reading. Only P1 and P2 could use smartphones, although they were not the youngest. Both of them mainly got access to the latest news from an APP called Teletext. It originated from a service for hearing-impaired people by subtitling TV programs. Later, it turned into a service used by many older viewers to search text information with remote controllers. However, many broadcasters had announced to cancel Teletext due to the rise of the Internet. Both P1 and P2 mentioned that they liked to use this APP mainly because the interfaces and interaction were very similar to what they used on televisions.

Participant	Frequency	Preferred Content
P1	3-4 times a week	Local events
P2	Once or twice a week	Local events, global events, politics, weather
P3	Once or twice a week	Local events, latest news, opinions, weather
P4	Not applicable	Not applicable
P5	Every day	Local events, obituary, puzzles, historical story
P6	Not applicable	Not applicable
P7	Not applicable	Not applicable
P8	Once or twice a week	Local events, headlines, TV schedule

Table 5-2 The participants' frequency of reading shared newspapers and preferred content

- *Habits and Preferences of using newspapers*

As shown in Table 5-2, although shared newspapers were provided in public spaces every day, most participants did not read them frequently. They preferred to read print media in their rooms without interference. P3 said he liked to read alone for better privacy. P1 and P8 had a habit of taking their own newspapers to the public areas in case of being alone or having nothing to do there. P2 and P3 also mentioned they only read the shared newspapers when they were waiting for their friends. Only P5 read the newspaper in the public space every day because she felt lonely reading in her room: "*It is not necessary to talk to others. Being outside with other people is enough.*" P5 also liked to touch newspapers to facilitate reading, but P2 and P8 usually avoided getting "dirty fingers". Local news, especially the news related to their past life or the news that took place in their neighborhood, was their preferred content in common. They also had some personal preferences, such as columns and TV schedules. Regarding other reading habits, P3 and P8 usually started with headlines and images. They only read detailed information if they were very interested in it because reading long and small texts would be very exhausting.

Participant	Newspaper	Newspaper with Digital Information	Digital Information
P1	Unattractive	Attractive	Unattractive
P2	Unattractive	Attractive	Unattractive
P3	Unattractive	Attractive	Neutral
P4	Unattractive	Neutral	Unattractive
P5	Attractive	Very Attractive	Unattractive
P6	Unattractive	Attractive	Neutral
P7	Very Unattractive	Attractive	Neutral
P8	Neutral	Very Attractive	Unattractive

Table 5-3 The participants' perceived attractiveness of three media forms

- *Perceived Attractiveness*

Table 5-3 shows a comparison between the participants' perceived attractiveness of the three media forms. Most of the participants took negative attitudes towards reading shared newspapers in public spaces mainly because it took much more effort. However, P6 missed the feelings of reading newspapers, so she had to ask her daughter to read for her once a week. P7 said newspapers were not interesting at all, and the articles were much less convincing than videos. Most participants claimed that the public spaces were built for social interaction rather than reading. Although they admitted that they often read shared newspapers in public spaces when they were waiting for social contacts, they did not treat it as an attractive activity. Only P5 held a positive view because reading shared newspapers was an important daily routine for her to experience the social atmosphere.

Their attitudes towards the combination of newspaper and digital information were encouraging. P7 thought it would be a different experience, even more interesting than watching television. "*Television news always plays too fast to follow, with this, I can watch it over and over.*" She said. P4 and P6 said they just needed to read the titles and acquire detailed information from videos and images. P2 and P3 liked the real-time feature

of digital information. They could keep checking the digital updates from the newspaper if they wanted to know how the news developed. P5 and P8 would like to watch the digital content after reading. They wanted to know more information that could not be printed on the limited layout space. "*I want to see every picture. I don't want to miss anything.*" P5 said

However, when we only displayed the digital information, their general attitudes changed again. Five of the participants were not enthusiastic about it. They thought it was almost the same as television. They already had a television in the canteen, but caregivers only turned it on when there were special events. The participants said it would be disturbing if the TV programs could not suit their interests. Some participants had a sentimental attachment to newspapers. P5 said she would miss the feelings of touching newspapers. P8 said she felt much more comfortable with newspapers because she could control the rhythm of reading. P1 and P4 felt confused and stressed because they had no idea how to interact with the digital content.

Participant	Newspaper	Newspaper with Digital Information	Digital Information
P1	Unlikely	Neutral	Neutral
P2	Unlikely	Likely	Unlikely
P3	Very Unlikely	Likely	Likely
P4	Very Unlikely	Neutral	Unlikely
P5	Neutral	Likely	Likely
P6	Unlikely	Likely	Likely
P7	Unlikely	Likely	Neutral
P8	Very Unlikely	Likely	Neutral

Table 5-4 The participants' perceived sociability enabled by three media forms

- *Perceived Sociability*

Table 5-4 indicates the participants' perceptions of the sociability enabled by using the three different media forms in public space. As mentioned above, most participants thought newspapers were difficult to trigger conversations. "*When people come to sit with me, I would close the newspaper.*" P8 said. P4 and P6 were mainly restricted by their physical conditions. They felt it difficult to remember the detailed information or even describe it to others.

Similarly, P8 worried others could not understand her because many residents had different cognitive or sensory impairments. P5 said she rarely shared the news with others and others were not likely to talk to her when she was reading. But sometimes, she would ask for help if she could not solve the crossword puzzles.

Most participants agreed that the augmented newspaper would be more likely to trigger social interaction. One reason was that the integration of print and digital media could easily arouse others' attention and curiosity. It could transform reading newspapers from an 'isolated' behavior to a 'public' one. Another reason was that it could lower the social barriers caused by their physical limitations. It would take much less effort to explain or understand. In addition, they all hoped the size of the digital display could be larger than the tablet for better sharing. "*But not too big, that would be too much and disturbing!*" P2 said.

The participants held different opinions on the sociability enabled by digital information only. P3 and P5 thought it was still likely to trigger social interaction if they could watch the digital content together. P2 and P4 thought it was unlikely because they felt no connection to it if they could not influence the digital information. P1, P7 and P8 held a neutral opinion. They thought it mainly depended on the situation and the presented content. If they had nothing to do and happened to watch the news they like, they would probably talk about it.

- *Preferences of Digital Information*

Among the digital information that we prepared, all the participants selected digital videos and images as their favorite forms mainly because they can offer more direct and vivid information. Besides, they felt more emotionally involved in the news through videos and images. Furthermore, they all agreed that videos and images were more convenient for sharing than texts. Although some participants thought the sound was also very important as compensation for their declining vision, they did not like the audio-only presentation because they had to concentrate to keep up with the pace, especially in public surroundings. None of them were interested in people's reactions from social media due to the lack of connection. Only P2 could use social media, but he only interacted with his family.

5.2.5 Key Design Requirements

To generate a preliminary design, we used the USAP deployment matrix to find the relationships between the participants' feedback and system specifications (Figure 5-3). The participants' related feedback was summarized and listed in the rows of the matrix. The design specifications were based on a framework for supporting natural interaction with printed matter in ambient intelligence environments and listed in the columns (Margetis et al., 2015). The framework was proposed to facilitate developers and designers to enhance printed matter with digital information according to their particular context. Although there are no set procedures for analyzing the chart, designers need to initially check each row and column for strong relationships (Sivaloganathan et al., 2001). The key design requirements were concluded in the order of priority:

1) The interaction with newspapers should be simple, effortless and interesting.

2) The interaction with digital content should be as simple as possible.

3) The digital interface could be designed with familiar elements for older adults.

4) The system should allow residents to freely decide the content and time to augment.

5) Videos and images are the main forms of digital content.

6) The digital information should be continuously updated.

7) The systems should be used by individuals or shared in small groups rather than the whole public area.

8) Residents' common interests are the primary content to augment.

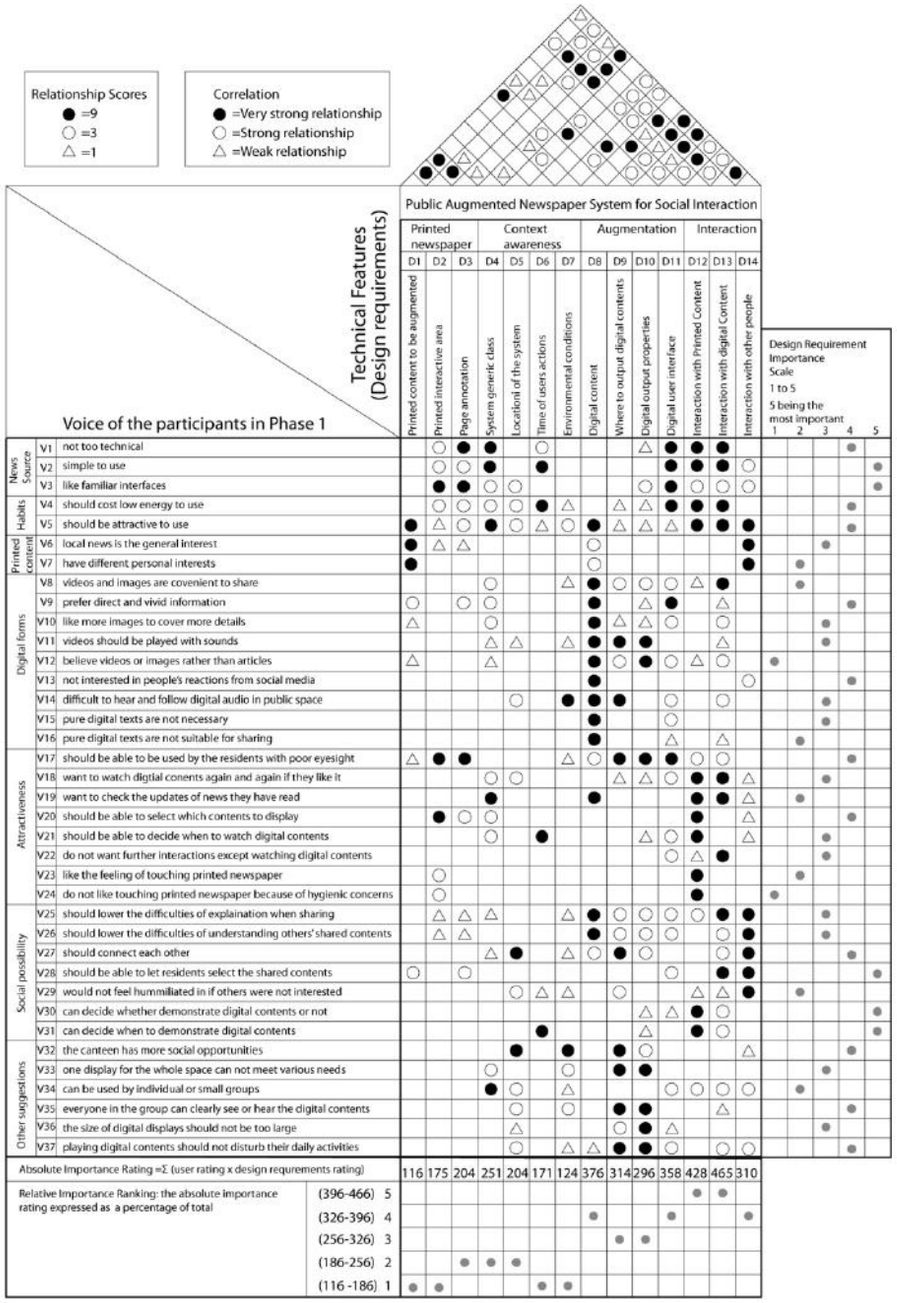


Figure 5-3 The USAP deployment matrix was employed to identify key design requirements.

5.2.6 Reflections on Ideation Process

Our practice in the Ideation phase demonstrated that nursing home residents are willing and have the ability to participate in the early-phase development of novel systems. The design outputs prove that the chosen method can capture residents' design requirements and map them to the system specifications. Although preliminary, our design concept can satisfy residents' individual and social demands and is technically feasible to construct a functional prototype for the following phase. The challenges in this case mainly come from the uncertainty of the system to be designed, residents' limited knowledge of modern technologies and their physical barriers to engage in conventional co-creation activities. The key to success is to take advantage of residents' life experience and designers' professional knowledge. The co-creation approach in this case was mainly led by designers, which is consistent with Sofia Hussain's (2012) study indicating that designers should design and lead the co-creation activities in the initial phases of design projects with marginalized people. Through designers' work, the participants can better understand the design task and become more confident to collaborate with de-signers in the later phases, and even take the lead. Regarding specific techniques, since many residents are vulnerable to their surroundings, we chose to collect user requirements in a mild way mainly by active dialogues rather than task-oriented activities, which also proved to be effective. The key to the successful involvement of residents in ideation is not to push the complexity of technology, but to provoke them to talk about their related habits, past experience and barriers. We also found that the critical discussions on the comparison of related daily products or services were much easier for the participants to identify their real demands. In addition, this study also shows the advantages of hosting design sessions at the site where the systems might be installed in the future. It is helpful to create a comfortable atmosphere and reduce the participants' effort to imagine future scenarios. Additionally, our findings showed that the participants had positive attitudes and perceptions of the envisioned IPD system, which confirmed our design assumptions and showed the potential to apply such a system in the future. The design implications deriving from this study could also inform the system design in related fields.

5.2.7 Preliminary Design of Reading-to-Sharing (R2S)

Figure 5-4 An overview of the preliminary design concept: Reading-to-Sharing (R2S)

Through the ideation sessions, we investigated residents' acceptance and perception of the system aimed at augmenting their experience of reading newspapers in public spaces. Besides, several key design requirements of such systems were collected. We found that many of these requirements were very consistent with the implications from the field study of OutLook (Section 3.4.6), which initially validated the key design factors, especially those on interface, interaction and content. Although these design criteria were still very general and not enough to construct a completed system for field tests, they can guide us to initially explore a design concept to be further refined with residents in the following sessions. Therefore, a preliminary concept called Reading-to-Sharing (R2S) was constructed based on these design requirements.

As shown in Figure 5-4, R2S is a tabletop system distributed in the primary public area of care homes. Each unit of the system mainly consists of a tangible tool, newspapers enhanced with special marks (colored circles) and a digital display running R2S application. The marks can indicate the interactive areas on the newspapers. These areas are specially enhanced by related technologies for printed matter recognition. The tangible tool is a wireless tabletop device to identify each mark. It has a concise appearance with a white cylindrical body and a red switch at the top. It can stand steadily so that users do not need to keep holding it. Residents can decide when and which content to augment. They just need to place it on a certain mark to get access to corresponding digital content from the screen. The digital media could be directly played online from news websites or social media so that residents can check the updates. The digital interface is also very simple. It directly displays digital videos or images with brief descriptions in digital texts. When no one uses the system, the screens display nothing to avoid disturbing.

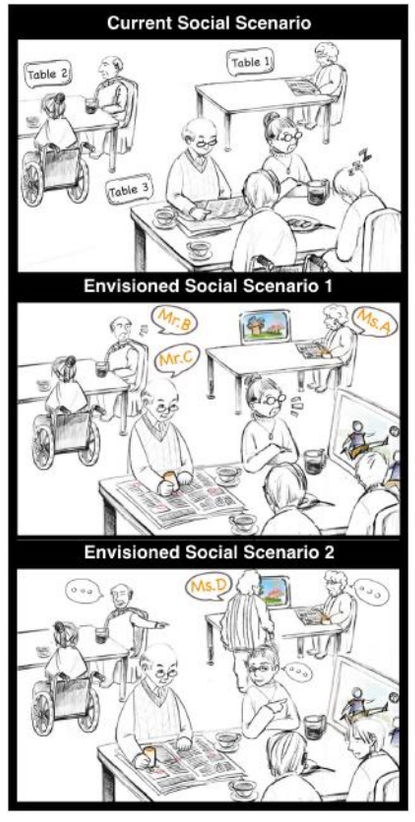


Figure 5-5 A storyboard that illustrates residents' current social scenarios in public spaces and two envisioned social scenarios after R2S is applied

Figure 5-5 depicts a storyboard of residents' current social scenario and two envisioned social scenarios with R2S. The current social scenario was built mainly based on the interviews in our context study (Section 4.3.5) and ideation sessions (Section 5.2.4). As shown in the current social scenario, Ms. A is reading newspapers alone at Table 1. Mr. B at Table 2 is looking around because he barely has anything to do with his social partner. Mr. C is sitting with his friends at Table 3, but they have few communications because he is reading newspapers. From the first envisioned scenario, we can see that R2S can not only enhance the individual reading experience by compensating for their sensory loss and providing more digital information but also socially connect the residents sitting together

(Table 3). From the second envisioned scenario, R2S can also create more social opportunities by attracting the residents passing by (Ms. D) or sitting at other tables (Mr. B).

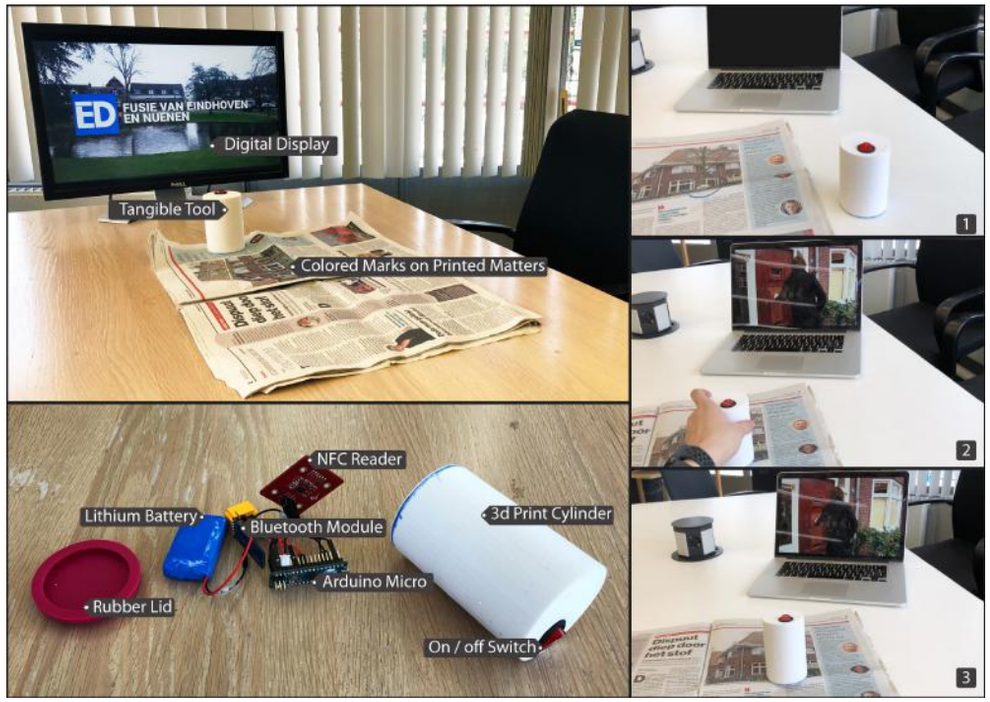


Figure 5-6 The low-fi prototype of Reading-to-Sharing (R2S)

Although many features of the system were still undefined, we believe that a functional prototype deriving from the ideation phase would be very helpful for older people to quickly understand and refine the preliminary design in the following phase. For rapid prototyping, we adopted NFC technology to bridge printed content and digital information. Multiple transparent mini NFC tags are attached to newspapers. As shown in Figure 5-6, they are surrounded by sketched blue circles. The shell of the tangible tool is 3D printed. An NFC reader (RC522) is installed at the bottom of the shell to recognize nearby NFC tags. The tangible tool can be paired with a computer via Bluetooth, which is realized by a Bluetooth module (HC-05) connected to an Arduino Micro board. The board is powered by a lithium battery (7.4V). It is also in charge of the data communication with the NFC

reader and computer. The R2S software application is simulated with a live-programming platform VVVV[1] that is characterized by real-time rendering and quick visualization. As shown on the right side of Figure 5-6, the identity code of each tag can be read by the tangible tool and sent to the computer via Bluetooth. The simulated application can receive the code, link them to related local or online media files and then display them in a renderer. Since our ideation sessions indicated that many residents lacked the ability to envision a novel system that they had never seen before, this prototype would be very helpful to embody the preliminary concept and provide the opportunities for the participants in the next phase to truly experience rather than just imagining.

1 *https://vvvv.org*

5.3 Refinement

As mentioned above, since the design requirements collected from the ideation phase were still general and not enough to construct a competed system, the preliminary design of R2S mainly served as a basic framework for refinement. Some features of the system were still undefined or temporarily defined based on designers' assumptions, which needed to be further confirmed or challenged by nursing home residents. In this section, we describe our exploration to involve nursing home residents in the refinement phase. Compared with in the ideation phase, their involvement level was higher because we believe it would be easier for them to refine visualized concepts and prototypes than proposing ideas to design something that they had never seen before.

5.3.1 Method

To refine the preliminary design with residents, we used a combination of co-creation techniques and social research methods suggested by Pilemalm (2007). The techniques include critical discussions of video demonstrations, storytelling, hands-on experience, collaborative prototyping and sketching. The social research methods include semi-structured interviews and observations. Given the difficulties for many older participants to understand and propose suggestions on system specifications from technological perspectives, we used the "Form, Interaction and Function" model proposed by Frens, et al. (2003) as a general principle to guide the design of interview questions, data collection and analysis. This model defines the interactive products through their form, interaction and function, and has also been used to design interactive systems that are pragmatic, attractive and easy to use (Frens et al., 2009; Hengeveld, 2011). For a better understanding, we interpreted this model into three questions from older users' perspectives: "*What should the system be able to do?*" "*What should the system be like?*" and "*How would I use the system?*" According to the model, these questions could correspond to different system specifications, but also inherently relate to each other. The data collected included audio-recordings of the interviews, the sketches and the photos taken during each session. The data were transcribed and analyzed using thematic analysis techniques

(Braun & Clarke, 2012)., and the findings can guide the refinement of the preliminary design from the three dimensions of the model.

5.3.2 Setup and Participants

Participant	Gender	Age	Length of Residence	News Source	Reading Frequency
P1	F	82	9 years	TV, newspapers	Always
P2	F	92	11 years	TV	Never
P3	M	65	1.5 years	TV, newspapers	Always
P4	F	70	2 years	TV, newspapers, smartphones	Rarely
P5	M	84	5 years	TV, newspaper	Sometimes

Table 5-5 the basic information of the participants (reading frequency: frequency of reading newspapers in public spaces. Sometimes: 3-4 times a week; rarely: 1-2 times a week.)

This part of the study was conducted in the canteen of the same nursing home as in the ideation phase. The canteen is the main public area where most residents would like to stay when they go out of their private rooms. We firstly acquired permission from the managers, and then the residents were randomly invited in person in the canteen. Given many participants' reading or writing difficulties, consent was given orally before each session. Five residents agreed to participate. Table 5-5 gives an overview of their basic information. Reading Frequency refers to their frequency of reading newspapers in public spaces in the nursing home. All of them had the basic hand function to eat independently, but only P5 could walk independently.

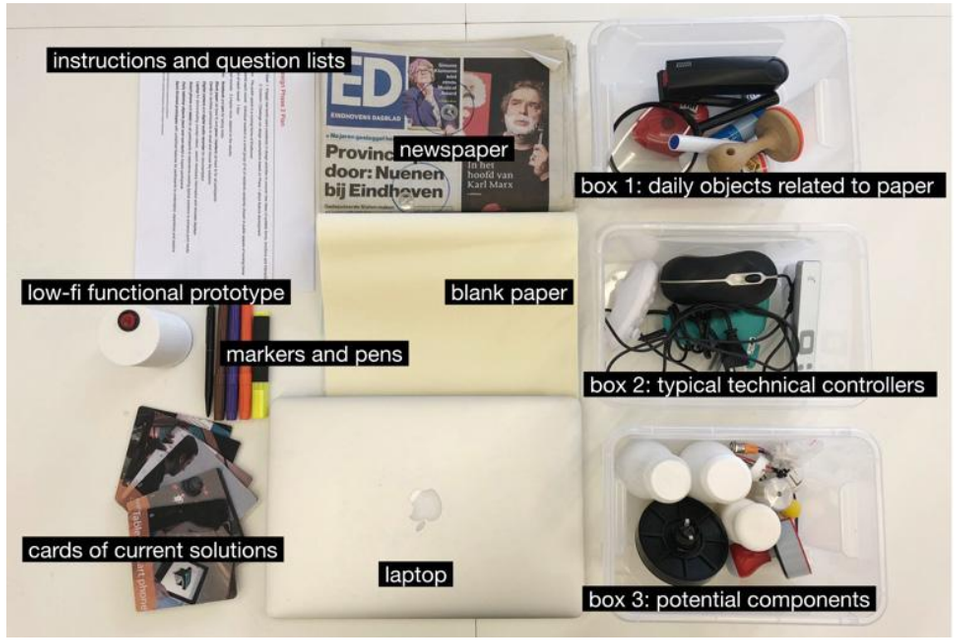


Figure 5-7 The tools and materials used in the refinement phase

In total, we had five refinement sessions. Each session was conducted with one participant during our visit to the nursing home. Figure 5-7 shows the tools and materials that we brought to the nursing home in each session. Besides the low-fi prototype of R2S and some necessary materials, we prepared three boxes of design references to facilitate the refinement with our participants. Since the design requirements from the ideation phase indicated that the participants preferred familiar interfaces and interaction, but they often had difficulties in describing which kind of design they liked, we collected some common objects that might inspire our participants. The first box contains some daily non-technical objects that are often used on paper interfaces including a stapler, a magnifier, a stamp, a glue tape roller, a marker and a glue stick. The second box contains some common technical controllers such as a mouse, a remote controller, a small gamepad with a joystick, a pen-like scanner and a gun-like scanner. In the third box, we prepared some electronic components such as some buttons, dials, joysticks in different forms and sizes that can be added to other devices. The boxes would not be used unless they expressed their needs for references, so that their thinking won't be restricted.

5.3.3 Procedure

1.Introduction (5 minutes)

Each session lasted about 1 hour in total. It was started with a brief verbal introduction to inform the participants that we hope they could help us to further develop and refine our preliminary design of an interactive system. The system could present related digital information when they were reading newspapers in public spaces. They were encouraged to express any comments, suggestions and questions at any time.

2. Demonstrations of related existing solutions (10 minutes)

After the short introduction, we showed the participants six videos of existing technologies or systems to augment paper interfaces and asked their opinions during each demonstration. The purpose was to enhance their understanding of such systems and give the participants a wider vision of current solutions to avoid restricting their minds within our own design. The six videos presented three kinds of solutions that were already available on the market but designed for other contexts. Table 5-6 gives an overview of the solutions from the three aspects mentioned above. After showing all the videos, the participants were asked to generally compare them, choose the solution they like or dislike, and then describe the reasons. During this, we presented six cards that represent each video to help recollection.

3. Demonstration and experience of the preliminary design (15 minutes)

In this stage, we presented the preliminary design of R2S by showing the participants a 1-minute animation converted from the sketched storyboard (Figure 5-5). The video demonstrated their current typical social scenario and two envision scenarios after R2S was applied. We explained the details and asked their opinions in open-ended interviews simultaneously. After this, we offered the participants the functional prototype to experience for 10 minutes and to provide further feedback. We prepared four pieces of digital content related to the printed content from a local newspaper according to the residents' preferences reflected from the ideation phase. They were a piece of entertainment news, a current event that took place in their neighborhood, real-time weather information and an image of crossword puzzles.

4. Collaborative refinement (30 minutes)

In the final step, the participants were asked: "*if you could change anything about the design, what and how would you like to change?*" They were encouraged to describe their ideas, and the designers would help to embody their proposals by drawing. If they had difficulties in visualizing their ideas, they could use the design references in the boxes. The participants could select their preferred forms, describe functions they liked to add and show the designer how they would use them. Regarding digital aspects of the system, we used a media player and a live-programming environment (VVVV) that is characterized by real-time rendering and simulation to quickly visualize the participants' proposals on the screen. In this step, the participants and the designers interactively engaged in a cycle of discussion, revising and previewing.

Solution	Form	Function	Interaction	
			With physical interface	With digital interface
Interactive tabletop with projection		Recognize pages by codes, track paper position, project interactive animations on the page and table	Flip the pages, move the papers	Touch and drag projected elements
Interactive tabletop with a multi-touch table		Recognize cards by code, track card position, display interactive information around cards on the screen	Put the cards on the screen, move the cards	Touch and drag digital elements
Augmented Reality book with PC and camera		Recognize pages by the camera above, track paper position, display digital effects above the page on the screen	Put the book under the camera, flip pages, move the book	None
Augmented Reality book with tablet		Recognize printed images with the embedded camera, track image position, display interactive animations above the image on the screen	Hold the device, point it at the page, flip papers, move the book	Touch and drag digital elements on the screen
Pen-like handheld scanner		Recognize printed texts, display interactive information on the screen	Hold the scanner, slide it on the paper, press the button	Touch digital buttons on the screen
Gun-like handheld scanner		Recognize printed codes, display interactive information on the screen	Hold the scanner, point it at the code, press the button	Select functions with the mouse, input information with the keyboard

Table 5-6 the demonstrated existing solutions

5.3.4 Participants' Feedback

In the following part, we summarize the participants' feedback throughout the refinement process from the three aspects of function, form and interaction.

- *What should the system be able to do?*

In Step 2, the participants' function-related feedback was very limited. The videos of the existing solutions were more likely to trigger their comments about form and interaction because it was much more direct and vivid to understand. Even though we kept explaining during each demonstration, it still seemed to be difficult for the participants to understand what these applications could actually do because they were designed for the younger generations and other contexts. "*I am too old for this. I can't learn this.*" P2 said. Their reflections were mainly about different ways to recognize printed content. When watching the videos of the augmented reality books, P5 said people living here were not familiar with computers and smartphones, but it might have future because the dynamic digital content would attract more people and could save the time of reading. He also said: "*However, people here would not like the cameras pointed at their tables. They would feel their privacy (have) been violated.*" P4 liked the solution of handheld scanners and said it reminded her of the barcode scanner from the supermarkets. "*People here can use this to select the articles they like and project them on the screen.*"

In Step 3, the participants could propose more ideas on content selection especially after they experienced the prototype. Local news was their common interest, which was consistent with the insights from the early phase. They also had some personal interests that could represent the preferences of similar groups. P1 liked puzzles and she thought the system was helpful for her to solve puzzles together with her friends. P2 addressed the importance of real-time content because many people here liked to read and talk about sports news. P3 thought the design was suitable to be used in small groups, and people could choose their preferred subjects. P4 preferred entertainment news because sometimes there were live performances in this canteen. Many people liked it, but they needed to pay for them. P4 also suggested that the

system could be used not only on newspapers, but also on magazines, photos, flyers of advertisements and even postcards. "*I have a sister living abroad. She sometimes sent me postcards. Maybe I can see her with this!*" P4 said. P5 said the preliminary design was much easier for him to understand than the videos of other solutions. "*Of course, it relates to personal preferences. Some people like reading newspapers. Some people don't.*" He said, "*But I think such thing is important to provide different things for people here to spend their time. Their life is too structured. No future, no challenges. They don't know how to spend their days and next days.*"

In Step 4, the collaborative explorations could trigger the participants to explore what else the system could do besides the very basic functions of the preliminary design. They tended to compare it with the devices that they were familiar with, such as televisions and radios. The result showed that all of them wanted to control the volume of the digital content. P1 said the canteen was too noisy to hear the videos sometimes. "*I cannot hear it unless I sit close to the screen.*" She said. P2 emphasized the importance of sound due to her poor sight. She said it was also very important when using the design in groups. "*The volume needs to be loud if the group is watching it, but it may disturb others if it is too loud.*" P4 also expressed her need to adjust the sound personally. She suggested the system could connect to some personal hearing devices so that everyone could set their own volume. P3 and P5 hoped they could control the volume with very low efforts. "*I lost one leg last year. I don't want to walk to the screen and bent over to control the sound if I can do it sitting here.*" P3 said. The participants also proposed other potential functions to meet their various needs. P1 and P4 were inspired by the remote control and thought it would be nice if they could pause the video. P1 thought the pause function would trigger people to discuss. P4 thought the pause could let her take a break if there was too much digital information. Besides, P1 also wanted to switch the images displayed because she was curious about all the details. P4 asked if she could zoom in and zoom out the images. P5 suggested that partly rewinding would be useful because people would easily miss the interesting part due to their sensory impairments and unstable environmental conditions. However, although we encouraged them to propose as many ideas as they could, all the participants repeatedly reminded us not to add too many functions. "*You must keep it simple. Just basic functions or people here will not use it.*" P2 said.

- *What should the system be like?*

In Step 2, the participants' form-related comments were very general and similar to what P4 said: "*It is beautiful! I like it.*" But when we asked how they would feel if we applied these solutions in this area, their attitudes changed. All of them held the view that the videos looked very nice, but people here do not like things that look technical. "*They look too futuristic. People may get curious, but most of them always keep a distance from the innovations*." P5 said. Most of their critical comments focused on physical interfaces. All of them thought the devices in the videos were too complicated, including P4 who did use a smartphone. P1 thought the interactive tabletops could be useful when the caregivers host activities, which could develop their brains, but it would not be suitable to use independently. P1 and P4 reflected that the screens of smartphones were too small to watch. Tablets were much better, but they were too heavy to hold. Compared with interactive tabletops and augmented reality books, the handheld scanners were easier for them to understand because they had seen them before. However, they did not like the technical appearance. Besides, they were not friendly to older adults. P3 and P5 said that it was difficult for many people here to keep holding devices. Besides, P5 said he did not like the barcodes on the paper, which look too abstract. "*I don't like it and don't trust it.*" P2 said she could speak for most residents because she has lived here for a long time. She emphasized that people here fear unfamiliar things. They would not use or share it if it looked too technical.

In Step 3, the animated storyboard and our simultaneous explanations provided them with a general understanding of the design. They all agreed that the canteen was the ideal location to install it because this was the most popular space in this nursing home. P1 suggested the information should be displayed on bigger screens than the laptop we used. P2, P3 and P4 liked the idea of distributed units because they used to share one big display in the whole space when there were some activities. But many people could not watch or hear it very clearly, and different people had different interests. These complaints were also reflected in the early phase, which further confirmed our design decisions. P4 also suggested that these displays could be folded under the table when not being used. Most of their feedback was still focused on the physical interfaces. Although we asked them about digital interfaces, most of them only wanted to watch images or videos from the

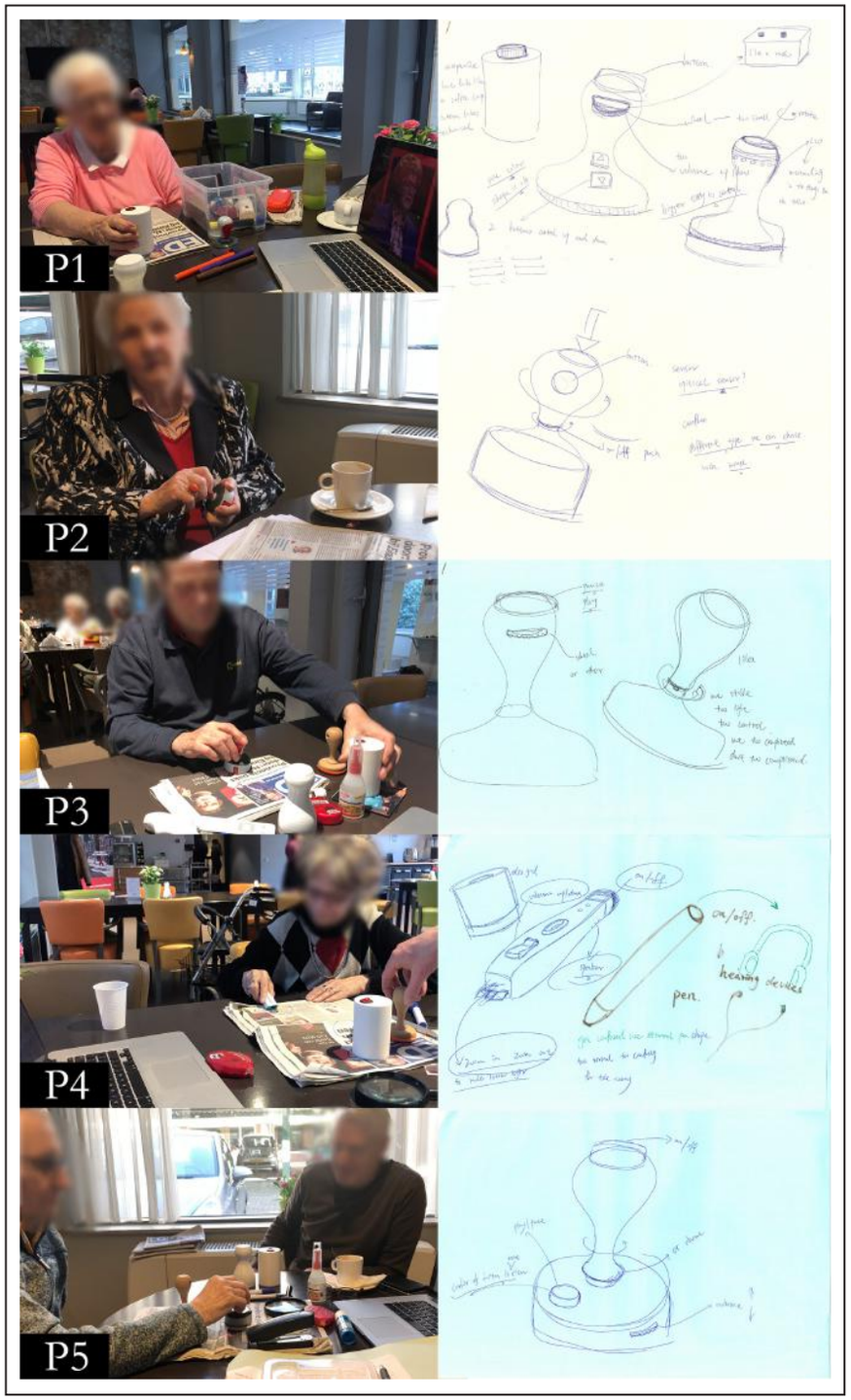


Figure 5-8 the design proposals of each participant (sketched by designers)

display. They hoped to keep the digital information as simple as possible. When experiencing the prototype, all of the participants except P3 had difficulties finding the marks on the newspaper when they were holding the tangible tool. But they could quickly understand and use independently when we pointed them out. They suggested that the marks should be clearer and more obvious. P5 said: "*Maybe a different color. Maybe a different shape.*" Regarding the tangible tool, most participants were basically satisfied with its current form, especially its size and weight. Some participants also propose their opinions for improvement. P1 said the tool looked too much like a coffee cup, which would easily lead to residents' confusion. Besides, the size should not be too small, otherwise people would not notice it or feel difficult to find it. P2 hoped it could be more attractive because the current form was too ordinary.

In Step 4, we encouraged the participants to propose specific solutions to refine the current physical and digital form based on their requirements in previous steps. However, it seemed they had little enthusiasm for the digital aspects. All their feedback was still focused on keeping them as simple as possible or using their familiar interface like televisions. P1 suggested there could be some simple instructions on the screen to guide people to use it. Regarding the physical aspects, it also seemed difficult and stressful for them to describe their own solutions than criticizing videos or the preliminary design. The reference objects turned out to be very helpful to facilitate the process of the collaborative refinement of the physical interface. After trying the objects, they selected their favorite form. As shown in Figure 5-8, P4 thought the tangible tool could be like a pen while the other four participants selected the stamp as an ideal shape. P4 made the choice because she was attracted by the video in Step 2. She thought the shape was very comfortable and easy for her to use. Besides, if the system were installed on many tables, it would be convenient to carry it to other places. However, P2 and P5 hold a different view that there were usually normal pens on the tables, which would make people mix them up and feel confused. P2 also expressed her concerns about security: "*The pen was too small to be found on the table, and people will easily take it away.*" P3 remarked that many people could not properly use pens due to shaking hands. P1 was satisfied with the shape and size of the stamp. She thought it was important to freely move it around like playing chess. In addition, it was easy to draw residents' attention because they had

never seen stamps on the tables before. P2 thought the shape of the stamp could motivate people to place the tool on paper. P3 and P5 also liked the shape because it was effortless to pick up and drop down than other objects. Furthermore, P1 and P5 thought the stamp looked much nicer because most tools related to paper were for work or study. "*It is strange to use these because people here do not study or work anymore.*" P5 said. He also pointed out that no residents would prefer assistive tools like the magnifier that might make them feel stigmatized. None of the participants proposed material-related requirements unless we asked. Most of them preferred plastic tools than wooden ones because plastic was easier to clean if it would be used by many people. P2 and P5 also thought using wood was too old-fashioned.

- *How would I use the system?*

In Step 2, the participants' interaction-related comments were very similar to each other. All of them claimed that touching or dragging on digital screens was too complicated for them. P1 said: "*My granddaughter taught me many times, but I still cannot use it (tablet).*" The tangible scanners were much easier for them to accept and understand. The interaction with the pen-like scanner was more preferred because holding the gun-like scanner in the air was very difficult for many older people, not to mention they needed to point the scanner at a certain area on the paper.

In Step 3, all the participants could quickly understand the basic interaction of the system from the storyboard animation. After quick instruction, they all could use the prototype independently although some of them have difficulties finding the marks. They agreed that the interaction was friendly for older people because it was effortless and required much less accuracy than the scanners in Step 2. However, when asked to develop more interactions that could integrate the functions and forms that they proposed previously, none of them could propose solutions by themselves.

In Step 4, given the participants' difficulties in designing interactions, we had to play a more leading role in this part by proposing more possibilities and visualizing their ideas by sketching. We found the participants relied on the objects in the boxes very much for inspiration and reference. As

shown in Figure 5-8, adding big buttons was the most common solution for the functions like "on-off", "play-pause" and "switch images". Most of them preferred to put the buttons near the handles so that they could easily press them when holding the tool. But P5 thought it would cause many maloperations when picking up and moving the tool around, so he chose to put the button at the bottom. As for the linear functions such as controlling the volume and rewind, P1 and P3 were inspired by the mouse wheel and proposed to adjust the volume by scrolling a gear embedded in the handle. P5 also wanted to add a wheel at the side of the pedestal of the stamp to rewind the videos. P4 suggested adding a special button. People could press its two ends to turn up / down the volume. P2 was inspired by her experience of using old radios. She thought it would be nice to rotate the handle like a dial. Besides sketching, we also simulated the digital feedback with fast programming tools (VVVV in this case) and media players to create more concrete scenarios for the participants. P5 gave up adding the rewind function after he watched the simulated effects. "*It is too sensitive. The images are always changing. I guess people may not like this.*"

5.3.5. Reflections on Refinement Process

Our practice in the Refinement phase demonstrated that nursing home residents could collaborate with designers in the refinement of IPD systems. The three perspectives of form, function and interaction were not only easy to be accepted by older participants, but also useful to be a general guidance for the designers. Just as shown in the ideation phase, the importance of the selection of the site has also been identified. Robins (1999) proposed two approaches: "*Bring the designers to the workplace and bring the workers to the design room.*" Although design room has the advantage of easier access to equipment and technical experts, we believe the design activities involving nursing home residents should take place where the system will be applied because the real-life settings can reduce their efforts of imagination and take the environmental factors into account. Furthermore, researcher s have indicated that nursing home residents are more vulnerable to their surroundings than their independently-living peers (Fowles, 2000; Carstensen et al., 1986), so it is important to create a free and comfortable atmosphere given their physical inconveniences. In addition, although this study could not prove that individual activities were better than group activities, we agree with Neustaedter (2006) and Sanders' (2010) studies indicating that individual sessions are more appropriate to design completely new systems and work better in detailing stages. It is mainly because the refinement requires older participants' in-depth involvement rather than collecting parallel ideas, which is hardly ensured through group sessions. Our prior work (Section 5.2.1) also revealed the problem that older people with better health and stronger personalities would often be dominant in conversations and influence other group members. If it is necessary to involve multiple participants simultaneously, we suggest involving more designers and experts to support each participant. In addition, we found it is very important for the designers to keep paying attention to the participants' energy levels. The duration of each step should be more flexible according to participants' different physical situations, which could also show the superiority of individual sessions.

Our practice in the refinement also provides detailed implications of the techniques to collaborate with older people:

Although the video demonstrations of existing solutions have been frequently

used in the early-phase design activities, they would easily create preconceived impressions that might constrain older participants' creativity due to their limited understanding of novel technologies. Our experience indicated that showing existing solutions was more appropriate in the refinement phase.

We found that the videos were able to broaden participants' minds and provoke their critical discussions. The key was to make simultaneous explanations and ask open questions during the demonstrations because it was very difficult for them to remember the details even though we prepared cards to help them recall.

We also learned that it was important to control the length and number of the videos. Designers should select the most representative solutions and keep each video short. We presented 6 videos in this case, which seemed to be beyond some participants' ability to process the new information. They appeared to be uncomfortable when watching the last few videos, which certainly affected their contributions in this step.

From the data we collected, we found the videos were more likely to trigger participants' comments on the form and interaction than the function of the systems. The reasons could be that they were unfamiliar with the technologies or the contexts, and some functions could not be directly shown through videos even though we explained.

The animated storyboard was very useful to help the participants quickly understand the usage scenarios of the preliminary design. However, such understanding still seemed to be very superficial. It might be because the storyboard could not fully illustrate some functions and details. It might also be because sketched animations are not as easy to understand as live-action videos.

The hands-on experience of the functional prototype proved to be very effective for the participants to fully understand the concept and facilitate them to refine the system. We could tell the obvious differences of the participants' facial, verbal and bodily reactions before and after they experienced the prototype.

We also found that using functional prototypes was more likely to trigger participants' ideas on functions. It seemed that such prototypes could effectively reduce the participants' efforts of imagination and increase the fun of creativity. In Step 4, the participants' major efforts were spent on embodying their preferred functions in suitable form and interaction, which was very challenging even for younger people. Although there was no fixed procedure, we found that all participants started with refining physical interfaces because they thought it was the most important and familiar part.

The design references turned out to be very useful, even though we had concerns about the side effects to constrain their ideas. To minimize the side effects, we suggested that the selected related design references should be representative and have diverse features.

As for refining digital features, the participants showed little interest and confidence. Although sketching has long been a widely accepted technique in participatory design, we found it was not as effective as expected when refining the digital aspects of interactive systems for older people because it is abstract, static and non-interactive. The live-programming platform (VVVV) that we used to simulate some digital feedback and effects proved to be helpful for the participants to preview the result. Therefore, we identified the need to develop more related hardware-software toolkits for rapidly visualizing concrete, dynamic and interactive design proposals for older adults.

5.3.6 Refined Design of Reading-to-Sharing (R2S)

- *System overview*

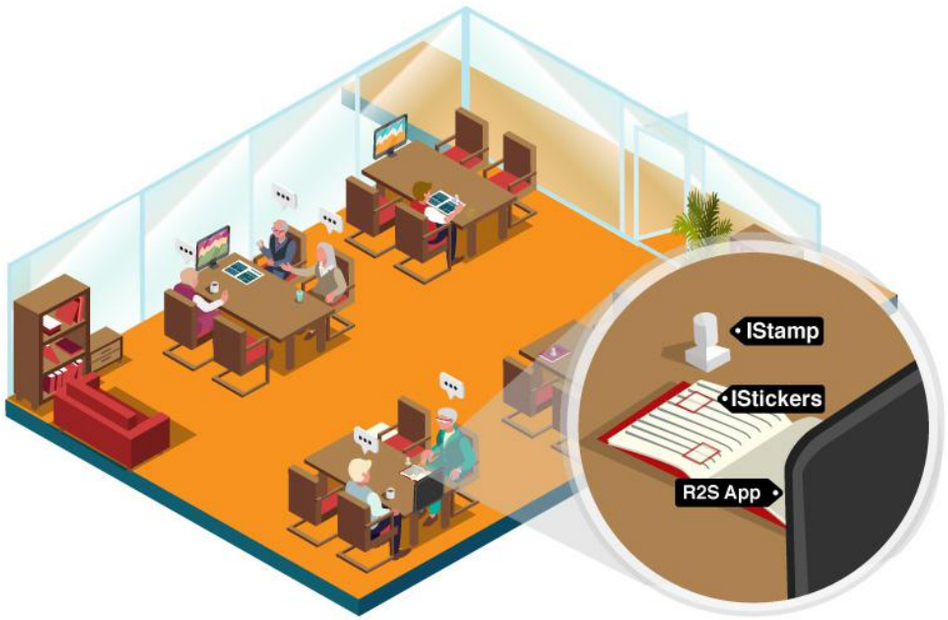


Figure 5-9 An overhead view of R2S applied in nursing homes.

The preliminary design of R2S was refined based on the participants' feedback. As shown in Figure 5-9, the refined version of R2S consists of a series of tabletop units distributed in public areas of nursing homes. Each unit of R2S consists of three parts: (1) a tangible tool called IStamp, (2) multiple specially designed stickers called IStickers and (3) a digital display running the R2S software application. The system provides a flexible platform not only for caregivers to convert any print media into interactive surfaces, but also for residents to easily access their preferred digital information at their preferred time. Just like the preliminary concept, the refined version can not only reduce residents' physical barriers of reading, but also create more social opportunities by demonstrating media preferences and reducing residents' efforts of communication.

- *IStickers & IStamp*

IStickers is a collection of stickers that can be attached to paper to create interactive areas. They are mainly used by caregivers to select or make printed media that would potentially appeal to residents. As shown in Figure 5-10, the stickers are transparent but highlighted with colored edges to indicate the interactive areas. IStickers look identical in the physical world, but each sticker has a unique code that can be identified in the digital world.

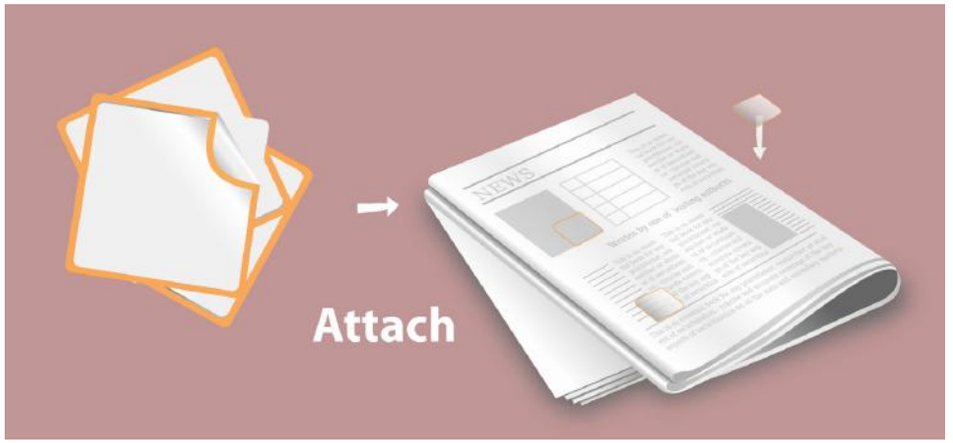


Figure 5-10 IStickers are used by caregivers to create interactive areas on print media products.

IStamp is a wireless device designed to recognize each ISticker and further interact with digital media. As shown in Figure 5-11, the appearance design of IStamp is inspired by conventional stamps. It is mainly composed of two parts: (1) The square base makes it stand steadily on the table; (2) the cylindrical handle makes it effortless to pick up and hold by users. Such a low-tech look was suggested by co-design participants to lower their physical and psychological barriers to use new technologies. On the one hand, it can blend in public care environments. On the other hand, it is distinguishable from other items on tables to arouse residents' curiosity.

The basic interaction with IStamp is straightforward and effortless. To recognize each ISticker, users just need to 'stamp' on it (Figure 5-11). Since the shape and size of IStickers are designed to match the bottom of IStamp

exactly, users can easily learn the interaction. For the residents who are getting more familiar with the system, they can explore richer interactions by rotating or pressing the handle (Figure 5-11). They can further control the digital media such as pausing/playing, switching images and adjusting the volume. In addition, IStamp can provide visual and auditory feedback to invite residents, guide user interaction and play audio files (Figure 5-12), which is helpful for the residents with sensory impairments.

Figure 5-11 The basic and further interactions with IStamp.

Figure 5-12 The visual and auditory feedback of IStamp are designed to facilitate older users.

- *R2S application*

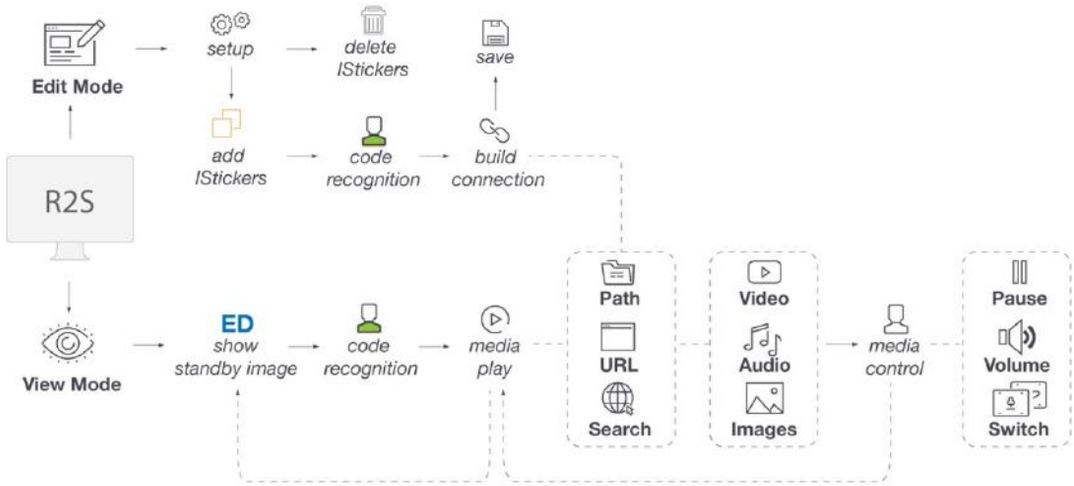


Figure 5-13 The R2S application has two modes. The Edit Mode is mainly used by caregivers to build the connection between IStickers and digital information. The View Mode is used by residents to watch and control the digital information.

To run the system, each IStamp needs to be paired with one digital display running R2S application. There are two modes in the application: The Edit Mode is designed for caregivers, and the View Mode is for residents (Figure 5-13). Although other stakeholders have been considered to prepare the content, e.g., media publishers, volunteers, residents' family, or even residents themselves, we believe that professional caregivers are the most ideal group to edit the content because of their understanding of residents' preferences and habits, the feasibility of which still need to be evaluated in the following studies. In the Edit Mode, caregivers can add IStickers to the system by 'stamping' on the stickers (Figure 5-14). After the codes of the stickers have been saved, caregivers can associate them to specific local or online media files. The system can also search real-time media files on the Internet by the keywords input by caregivers. After the quick editing, the system can be switched to the View Mode and left on standby for residents' use (Figure 5-15). Once they 'stamp' on IStickers, the application would directly demonstrate the corresponding media file. Residents can simply watch or further control the digital media with IStamp to facilitate their communications (Figure 5-16).

Figure 5-14 In the Edit Mode, caregivers can quickly add IStickers to R2S system by 'stamping'.

Figure 5-15 In the View Mode, R2S is left on standby for residents to use.

Figure 5-16 The resident is sharing sports news and adjusting volume with IStamp to facilitate communication with his social partner.

- *Prototype*

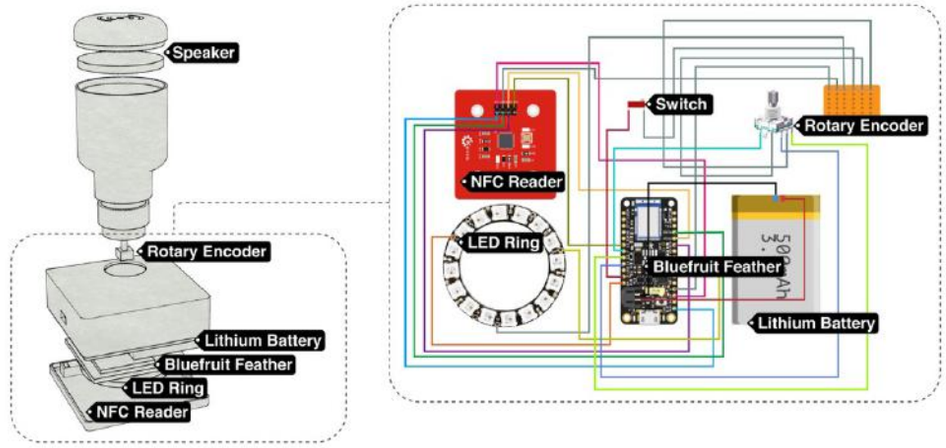


Figure 5-17 The structure and wiring diagram of the prototype of IStamp

We mainly adopt NFC technology to bridge the physical and digital world. Each ISticker is embedded with a micro NFC tag (5*5 mm with NTAG213 chip). IStickers are made of square transparent foils (5*5 cm) with colored edges (Figure 5-14). The shell of IStamp is 3D printed with the resin cured under ultraviolet (UV resin). As shown in Figure 5-17, it is powered by a chargeable lithium battery (3.7V). A rotary encoder with a switch is mounted at the joint of the base and handle so that the handle can be pressed and rotated. The handle is hollow and houses a mini speaker. The light feedback is realized by a LED ring mounted in the base. At the bottom of the base, an NFC reader (RC522) is installed to detect nearby NFC tags. The codes can be sent to the device with R2S application via Bluetooth. It is realized by the Bluetooth-Low-Energy (BTLE) module of a development board (Bluefruit Feather) mounted in the base of IStamp. The board is also equipped with a microcontroller (nRF52832) for data processing and communication. In this stage, R2S application is simulated with a live-programming platform VVVV that is characterized by multimedia interaction and visualization. The prototype program can receive, categorize and process the data sent from IStamp. The digital media files can be preloaded in cache or obtained via Uniform-Resource-Locator (URL) of related webpages or Application-Programming Interface (API) of social media sites.

行之愈笃 则知之益明。

The more you try, the more knowledge you will get.

–《朱子语类》<ZhuZiYuLei> [AD 1270]

Chapter 6.
Supervised Field Trial of R2S

6.1 Introduction

In Chapter 5, we described our practices of involving nursing home residents in the design and development of an IPD system for their social interaction. R2S was created as a promising design concept by digitally augmenting residents' daily experience of reading newspapers in public spaces. Although R2S was constructed mainly based on the participants' requirements and proposals, the system and related design factors need to be evaluated through user trials. Our experience from the case study of OutLook (Chapter 3) indicated that although open field trial has the advantage to capture residents' natural reactions and social interaction in their daily life, it was very difficult to get detailed insights on user engagement and user experience due to the restrictions of data collection in open field trials. Users' detailed behavior is difficult to be recorded by only taking field notes, and their experience is hard to be recalled afterwards, especially for older users. Therefore, we believe an initial evaluation should be conducted before the conventional open field trial. In this Chapter, we present a supervised field trial of R2S. It is a method between the controlled laboratory experiment and open field trial. The participants were invited to experience R2S in real-life settings with the presence and assistance of the researchers or care workers. The objectives were mainly to investigate user engagement and user experience of R2S. To provide insights for the following open field trial, we were also interested in the potential social impacts of R2S on residents' behaviors and feelings. Additionally, usability and design issues can also be identified for further refinement of the system. Part of this chapter has been published in the International Journal of Human–Computer Interaction (Kai Kang et al., 2022).

6.2 Setup and Participants

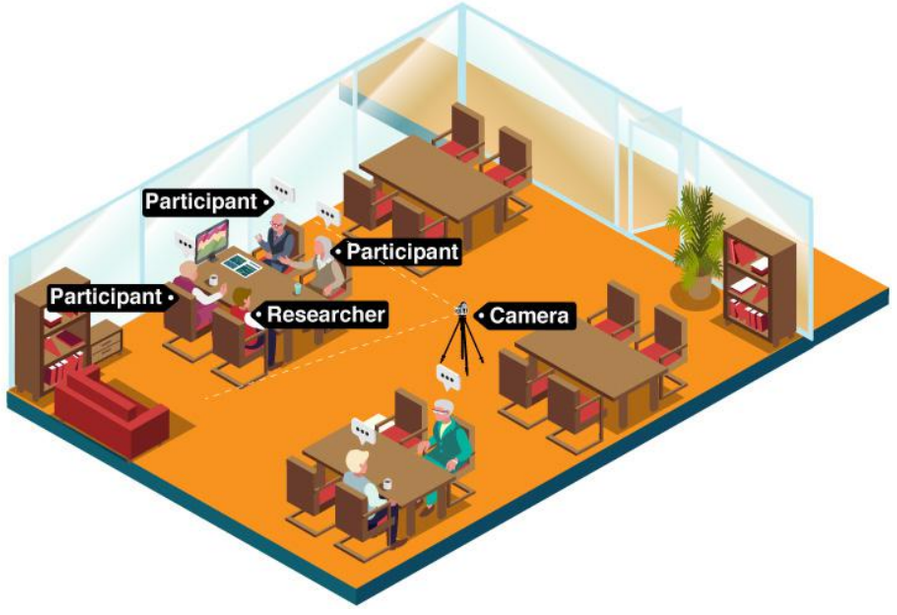


Figure 6-1 Setup of the supervised field trial

The supervised field trial sessions were carried out in two Dutch nursing homes (Home A and Home B). Both of them are affiliated with the same care organization that set up numerous similar nursing homes in Eindhoven. They were all equipped with rental apartments and various public areas where a wide range of activities could be organized. We evaluated the system by simulating a common scenario in which a group of residents sit at one public table. After consulting the care workers, we installed the system at a rectangular table (140*80 cm) within the cafe because it is one of the most popular areas and the central space for social activities in the nursing homes. As shown in Figure 6-1, we put a recent local newspaper on the table. Eight articles in the newspaper were preselected by the researcher to be augmented with IStickers. The information covers areas from neighborhood to international news. It also includes various genres such as anecdotes, sport, history and music. A 20-inch display was installed at one end of the table to present related digital media that was mirrored from a laptop running the R2S application. IStamp was placed nearby the newspaper. A video camera was set up pointing at the table and the display to record the experience sessions.

Since most nursing homes are special environments where residents with various backgrounds (health, education, work, family, etc.) live together, we did not have specific inclusion criteria as long as they could freely express their views. A total of 20 residents (9 males, 11 females) aged from 70 to 102 (M = 83.8, SD = 8.5) were recruited. Nine participants (4 males, 5 females) aged from 70 to 89 (M = 79.2, SD =7.1) were randomly invited to the cafe of Home A. They were referred to as low-care participants because they could arrange their social schedules independently and come to the cafe at least three times a week. Eleven participants (5 males, 6 females) aged from 74 to 102 (M =87.6, SD = 8.0) were invited by care workers in Home B. Due to the physical degradations, they were organized by care workers to take part in social activities in the cafe twice a week (high-care residents). They all had relatively normal cognitive functions because both nursing homes set up independent areas for the residents in the later stages of dementia. The participants joined the trial sessions in small groups or pairs (4 groups from Home A, 3 groups from Home B). The user trials were conducted during each of our visits. The groups from Home A experienced R2S with two researchers. The groups from Home B were accompanied by two researchers and two care workers. We firstly obtained permission from the nursing home management to conduct the study in their public areas. Given many participants had reading or writing difficulties, their consent was given orally and recorded.

Each session was started with casual group chatting for 5 minutes to understand their background (age, length of residence, information sources, frequency of coming to the public areas, etc.). As we expected, there was a big difference in their backgrounds in regard to their length of residence, education levels and careers before retirement. However, they shared many things in common because of their similar age and living environment. All of the participants got access to the latest news mainly by watching television in their rooms. Thirteen of them had the habit of reading newspapers. Most of the low-care participants read the free shared newspapers in the cafe. The care workers occasionally organized the high-care participants to read newspapers to them. Only one participant subscribed to personal newspapers and read in his room. Only two participants could use computers and smartphones. The basic information was very consistent with the related reports of nursing home residents' life and our findings in the design process of R2S.

6.3 Procedure and Data Collection

Figure 6-2 The participants are experiencing R2S with the presence of researchers.

Before the user trial, the participants were welcomed upon arrival and assisted to sit at the table where R2S was installed. The participants were served drinks and snacks as in their daily situations in the cafe (Figure 6-2). The researchers first briefly explained the research purposes and obtained informed consent. After the casual chatting, the participants were asked to fill out the modified Inclusion of the Other in the Self Scale (IOS) (Gächter et al., 2015) to rate their feelings of closeness with their peers at the table. Upon completion, the researchers introduced R2S by demonstrating a 5-minute tutorial video with simultaneous verbal explanations. Then, the participants were told that we were curious about their reactions, and in the next 15 minutes, they could freely use the system as they would do in everyday life. Their behavior and conversations would be recorded if they agreed.

During the user trial, the researcher turned on the camera if the participants agreed and configured the system to the view mode for them to use. The researchers and care workers sat with the participants as group members, but

they mainly played the role of viewers and would not prompt the participants unless they encountered problems, missed important features or asked for assistance.

After the user trial, the researcher turned off the camera and assisted the participants in filling out the post-procedure questionnaires including the AttrakDiff-Short (Hassenzahl et al., 2003) and the modified IOS scale. All the questionnaires were printed out in big letters, and thick markers were provided to facilitate the participants' selection. Upon completion, semi-structured interviews were conducted in groups for approximately 15 minutes to collect their feedback. At the end of each session, each participant was compensated with a gift voucher (10 euros).

During the whole study, we also interviewed four care workers (C1 and C2 from Home A, C3 and C4 from Home B). All the care workers had over 5-year professional experience in social care. Their jobs were highly involved in organizing scheduled social activities for the residents. They were invited to experience the system, compare the design with their current social interventions and provide their opinions.

6.4 Data Analysis

6.4.1 User Engagement and Social Impact

In order to understand how the participants engaged in using R2S and its potential social impact on their behaviors, we imported all the video data to Nvivo (11.4.0). Each participant's behavior was coded in turn across several cycles in the annotation process. Since numerous use behaviors and social behaviors took place simultaneously, and some communications were unrelated to the system, a two-round procedure was used. The first round focused on coding each participant's interaction with R2S. Based on the result of the first round, the second round was to annotate individual participants' social behaviors that occurred when they were using R2S.

The coding scheme in the first round was based on the PACD model (Memarovic et al., 2012). This model was conceptualized according to the

essential human needs in public space defined by Carr et al. (1992). The conceptualization can help with both the development and the analysis of public display applications. It describes three types of engagement with interactive public displays: passive engagement, active engagement and discovery. Since PACD was developed mainly based on the analysis of a conventional large stand-alone public display in urban settings, we slightly adjusted it to fit the features of R2S, our target context and the form of group trial. We mainly referred to the Menorah Park Engagement Scale (MPES) (Judge et al., 2000), which was initially developed to assess levels of engagement in adult day care patients during dementia programming. In the revised protocol, we added 'non-engagement' referring to staring into space or another direction away from R2S. Passive engagement pertained to brief interactions with R2S or observing others using. Most of them last for a short period (in seconds), e.g., they had glimpse interactions with the newspaper or screen. Active engagement was defined as longer (in minutes) or more focused interactions with R2S, either through active reading/watching, basic interaction with the user interface such as stamping, or the combination of the first two behaviors. Discovery refers to participants' interaction to explore more content and application features, e.g., the participants search more IStickers and try more functions and interactions with IStamp such as pause or volume control. In addition, in order to identify the potential usability issues, we coded the researchers' prompt when the participants needed external assistance.

In the second round of coding, our goal was to identify the participants' social behavior caused by using R2S. Due to the lack of appropriate coding schemes that exactly fit our context and purposes, we developed an observation scheme mainly based on the Social Play Continuum (SPC) (Broadhead, 2003). It distinguishes four levels of interaction categories that cover the spectrum from low to high degree of social behavior: Associative Domain, Social Domain, Highly Social Domain and Cooperative Domain. Since the SPC has been criticized by researchers for its complexity and unclear boundaries between the domains (especially the social and highly social domain), we also referred to the revised version of the SPC that were developed by Jansen & Bekker (2009). The social behaviors in our scheme were categorized into 4 levels: Non-social Domain, Associative Domain, Social Domain and Cooperative Domain. The Non-social Domain (ND)

refers to the moments when the participants paid no attention to each other. The Associative Domain (AD) is where the participants have one-way communication such as watching or reading together without talking, watching peer(s) use, self-talk, offering object but not accepted, and imitation. The Social Domain (SD) covers most basic reciprocal verbal or physical communications between the participants such as various forms of dialogues, eye contact, object offering and receiving. The Cooperative Domain (CD) refers to deeper communication to achieve shared goals such as offering and accepting physical or verbal help, identifying and solving problems together. In both rounds, we adopted the duration-based approach to calculate the time spent in each behavior category. The duration was then represented by percentages of the total experience time in each session (10-15 minutes).

6.4.2 Perceived User Experience

The participants' use experience was mainly assessed with the Dutch version of AttrakDiff-Short (Fischer et al., 2018). The questionnaire consists of 10 pairs of adjectives on the 7-point Likert scale clustering in three dimensions (Appendix A): pragmatic quality (PQ), attractiveness (ATT), hedonic quality (HQ). It was developed to assess the quality and user satisfaction of interactive systems. It has also been recognized as a handy method to evaluate systems in a public context (Fischer et al., 2018). Moreover, many studies used it as a friendly questionnaire for older people because of its simplicity to read and fill in (Pham & Theng, 2012). At the beginning of the study, we adopted the full version of AttrakDiff that consists of 28 pairs for more comprehensive information. However, it turned out to be an exhausting task for many participants. We had to reduce the items because many participants could not finish the full version. The records were transcribed into the online assessment tool to calculate the participants' ratings of their perceived use experience on each dimension.

6.4.3 Perceived Closeness

The potential social impact on residents' feelings was investigated with the Inclusion of the Other in the Self (IOS) Scale (Gächter et al., 2015). It has been proved to be a psychologically meaningful and highly reliable measure of the subjectively perceived closeness of a relationship (Cadieux et al., 2019). The scale is composed of one pictorial item represented by 7 pairs of Venn diagram-like circles (Appendix B). The two circles overlap on a continuum from a greater to a lesser degree. In each pair, one circle refers to the respondent and the other circle to their peer(s) at the table. The respondents were asked to select the pair of circles that best describes their perceived closeness. We selected this questionnaire because the simple pictorial form is very easy to read, understand and fill out by the older participants. Moreover, we believe it would be more acceptable for nursing home residents to avoid mentioning some sensitive topics such as "loneliness" that is often listed in other standardized questionnaires (Phillips et al., 2019). These advantages were helpful for smooth data collection and higher data reliability for evaluation.

Apart from the above-mentioned measurements, semi-structured interviews were conducted to gain a deeper understanding of the findings and results. The interviews were started by asking the participants' opinions of the design concept and envisioning their use in the future. Regarding user experience and usability, the participants were asked to describe their general feelings during use, the features that they liked and disliked, and the problems that they encountered. In terms of the social aspects, we asked them the effectiveness of R2S in motivating them to communicate with others and how they felt when they were engaged in using R2S with others. Before the end, the participants were encouraged to propose any suggestions. The transcripts were imported in Nvivo and manually analyzed using thematic techniques (Braun & Clarke, 2012).

6.5 Results

6.5.1 Findings from Observation

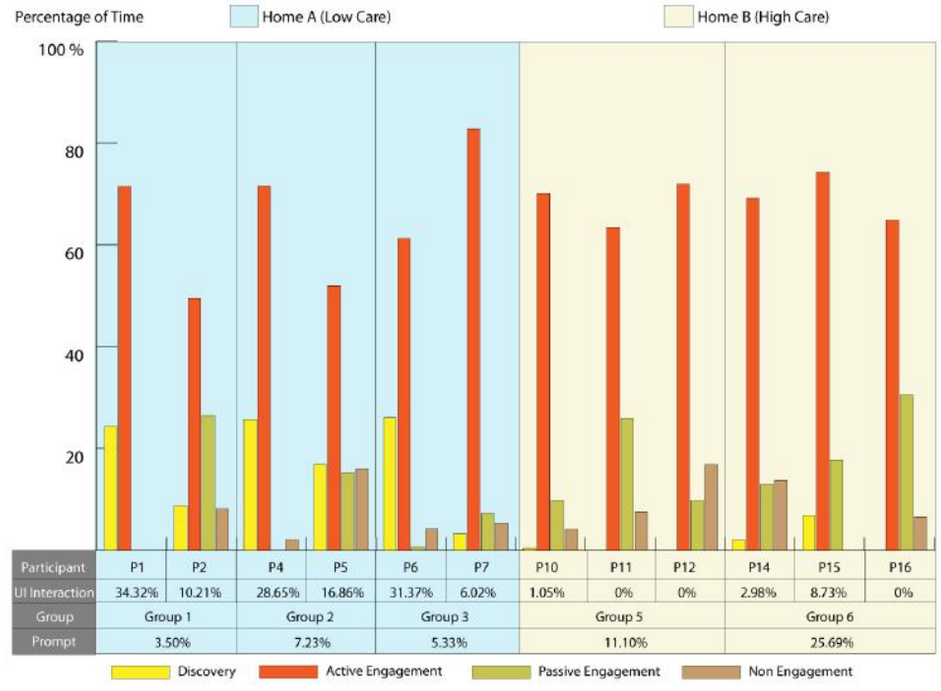
- *Usability Issues*

The videos showed that R2S put very low requirements on users' ability and their knowledge beforehand. After watching the video tutorial, we found almost all the participants could quickly learn the basic interaction and naturally 'stamp' on the stickers without our prompt. In regard to more diverse interactions, most of them needed short guidance in the beginning. Some participants thought they misused the system when they slightly rotated the handle but didn't receive any feedback. Therefore, the sensitivity of the rotary encoder could be higher. The most frequent prompt was found to be the identification of IStickers. Since the newspaper was filled with texts and images, it seemed to be very challenging for older people to find IStickers. In addition, we found that some participants preferred to hold the base of IStamp instead of the handle. They suggested that the size of IStamp could be a little bigger for a better grip. Apart from this, no obvious usability issues were reported.

- *Engagement levels*

We were allowed to collect and analyze the complete behavioral data of 12 participants in 5 groups. Figure 6-3 shows how the participants engaged with R2S during the experience sessions. The bar chart illustrates the percentages of individual participants' time spent in each category of engagement with R2S. It shows that all the participants were actively engaged in using R2S during most of their experience time (Mean=66.48%). However, we noticed that the low-care (Home A) and high-care (Home B) participants used R2S in different ways. As reflected in the table below, nine out of the twelve participants had directly interacted with IStamp. All the participants who did not touch IStamp were from Home B (UI Interaction in the table below). Besides, we found that the low-care participants spent significantly more time directly using IStamp with much less prompt from the researchers. Most high-care participants appeared to be more cautious and reserved to touch the interfaces. They preferred to ask the care workers or researchers to

trigger the digital display and watch the content. It is, therefore, reasonable to infer that the engagement of high-care participants might be much less active if they used it independently. The different use patterns could also explain why the low-care participants spent significantly more time in discovering the system (paired t-test, $p<0.01$) while the high-care participants were more passively engaged in using R2S.



Participant	P1	P2	P4	P5	P6	P7	P10	P11	P12	P14	P15	P16
UI Interaction	34.32%	10.21%	28.65%	16.86%	31.37%	6.02%	1.05%	0%	0%	2.98%	8.73%	0%
Group	Group 1		Group 2		Group 3		Group 5			Group 6		
Prompt	3.50%		7.23%		5.33%		11.10%			25.69%		

Figure 6-3 Bar chart: Participants' time spent in each level of engagement with R2S (min) / Participants' Experience Period (min); Table: UI Interaction = Participants' time spent in directly using IStamp (min) / Participants' Experience Period (min); Prompt = The time when participants needed assistance (min) / Participants' Experience Period (min)

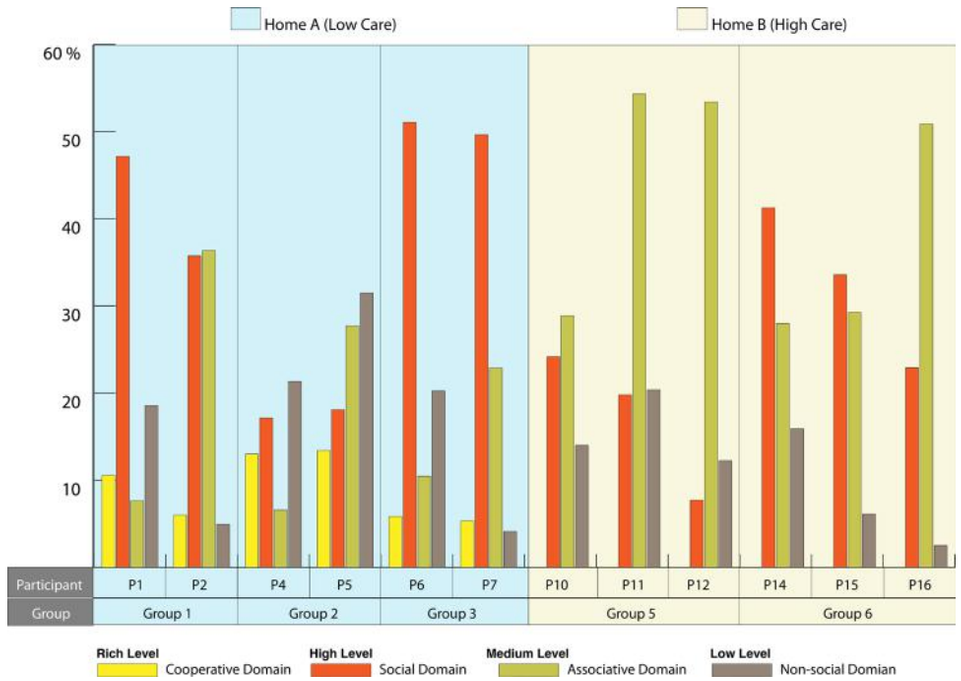


Figure 6-4 Participants' time spent in each level of social interaction caused by using R2S (min) / Participants' Experience Period (min)

- *Social interaction levels*

Figure 6-4 shows the percentages of individual participants' time spent in each level of social interaction with their peer(s). It shows that, although the groups differed in the distribution of social interaction levels, the great majority of the participants' social interactions fell into the social and associative domains. The percentages of the high-level social interaction were found to be the highest on average (M= 30.68%, SD = 0.14), and it is significantly higher than the percentages of non-social behaviors (paired t-test, p=0.0103), the average of which was 14.32% (SD=0.12). It indicated that the participants spent a relatively high proportion of their time in mutual communications. The average percentage of medium-level social interaction was slightly lower with higher variance (M=29.68%, SD=0.17). Additionally, it was easy to find that the average percentage of the cooperative domain was the lowest (M=4.51%, SD=0.05) because all the rich social interactions

were only observed in Home A, which could be resulted from the different ways of using R2S between the low-care and high-care participants. Given this, we also explored their differences in other social levels. We found that the high-care participants performed significantly more mediocre level social interaction than the low-care participants (paired t-test, p=0.013), with the respective average percentage of 40.77% (SD=0.13) and 18.59% (SD= 0.12), which might be because the high-care participants were more passively engagement with R2S. Additionally, the average percentage of the high-level social interaction in Home A (36.46%, SD=0.16) was higher than Home B (24.89%, SD= 0.12), but the low-care participants also had a slightly higher average proportion of the non-social behavior (MA= 16.78%, SDA=0.11; MB=11.86, SDB=0.07). No significance was found in both of these domains.

- *Engagement patterns in social domains*

To investigate how the use of R2S impacted residents' social interaction, the percentage of individual participants' social time in each domain spent simultaneously with the various degrees of engagement was measured.As depicted in Figure 6-5, the darker color of the stacked column represents a higher level of engagement with R2S. Overall, we can find the social interaction level increased when the participants were more engaged in using the system, which indicates that the potential social effect of R2S on the participants' behavior was positive. To further explore the relationship of the system features and their social effects, in the following sub-sections, we summarize the typical interaction patterns in each domain of social interaction, drawing from the statistics in Figure 6-5 and analyses of episodes of featured interaction.

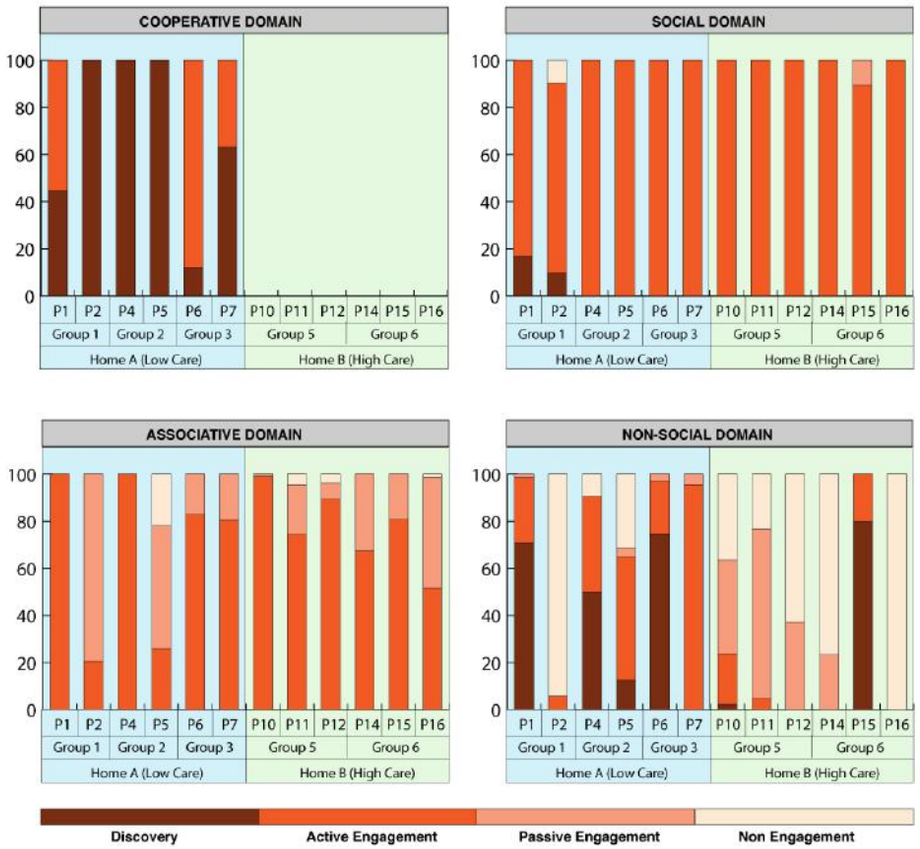


Figure 6-5 The stacked bar charts show how different levels of R2S engagement affected individual participants' social interactions in different domains (the volume of each column = Participant's time spent in each level of R2S (min) / Participants' social time in each domain caused by using R2S (min); the darker color of the columns represents deeper R2S engagement).

Cooperative Domain: All the rich social interactions took place when the participants were discovering or actively using R2S. The most common interaction was ***collaborative exploration*** of the system features or the content. Although the augmented newspaper was mainly designed for the primary operators to preview the content, we found that other group members could also be actively involved in this activity. They flipped the newspaper together to discover the potential content or try IStamp together to test the system feedback. In this process, we noticed some group members

had negotiation of content selection. They would propose or recommend their preferred content to display, and others might accept or reject their proposals. ***Collaborative problem solving*** was found when the group members had difficulties in searching IStickers. During this, they reminded each other if some important information was missed. Another common interaction pattern was related to ***social learning***. It mainly occurred because of participants' different degrees of understanding the system. In this category, teaching/learning behaviors were often recorded. Some participants with stronger personalities even show off to others or invite and guide others to use.

Social Domain: As mentioned above, the major components of the high-level social interactions were various forms of dialogues. Figure 6-5 indicated that almost all the interactions captured in this domain occurred when the participants were actively using R2S. We found that most annotated social interactions in this domain were ***mediated conversations*** that were triggered and maintained by the shared displays. These dialogues often occurred accompanying physical gestures such as pointing to the media content. Furthermore, we found a great majority of such communications were mediated by the videos. Watching and commenting on the video content without eye contact was one of the most common scenarios. They were used to start the conversations by discussing the details such as one specific object, person or location. The conversations mediated by printed content or digital images were also frequently recorded, but they seemed difficult to last long. In spite of being a conventional way of communication, ***direct conversations*** were lower in proportion. They were mainly observed near or after the end of each displayed content if the topics were extended to their own stories, common knowledge or jokes. These communications were often accompanied by physical expressions such as eye contact, performing and laughing.

Associative Domain: As shown in Figure 6-4, besides the social domain, the associative domain was another major category that we observed. Figure 6-5 indicated that the concurrent engagement levels with R2S were mainly active and passive engagement. When the participants were actively engaged, the most typical medium-level interaction was found to be ***watching together***, which was a common way to build the connection between the group

members. Associative reading was also occasionally observed, but it was only captured in Home A and accounted for a small percentage. It mainly took place when the participants showed great interest in the displayed content and wanted to know more details from the articles. In this category, we also found some participants tended to ***watch alone with self-talk*** when their peers were engaged in other activities or disengaged. When the participants were passively engaged, the most typical medium-level social interaction was found to be ***observing others***. It was mainly performed by viewers who didn't directly use IStamp. If some participants did not have enough motivation to join the primary operator in exploring the content, they tended to passively observe. This could explain in Figure 6-4 why some participants within each group have a significantly higher proportion of medium-level social interaction than other group members, and it seemed that observing was more likely to occur with the increase in the number of group members. This might also explain why the high-care participants showed a much higher percentage of the interaction in the associative domain because they spent the majority of the time being non-operators.

Non-social Domain: From Figure 6-5, we can see that the non-social situations could occur simultaneously with any level of engagement, which makes the compositions of the stacked columns in the non-social domain more complicated. We summarize three typical scenarios. First, the social behavior of one participant might stop when disengaged from group use, mostly because of being ***distracted*** by the external environment or other unrelated activities such as eating/drinking. Second, the non-social situations could also happen in ***parallel use with different attention***, e.g., some participants were reading details while some others were watching the digital display. Third, we found sometimes ***highly-focused use*** could also lead to non-social situations, e.g., when some primary operators were carefully reading the content alone, they might neglect to involve others.

6.5.2 Questionnaire Results

- *Perceived user experience*

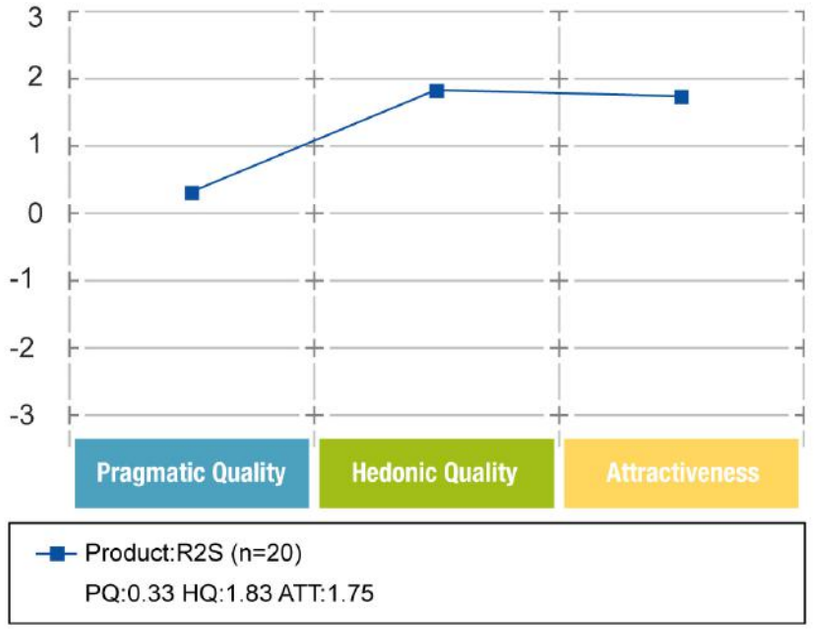


Figure 6-6 The average values of the three dimensions on the AttrakDiff-short questionnaire

Figure 6-6 illustrates the average values of the three dimensions on the AttrakDiff-Short questionnaire (N=20). The ratings for the Hedonic Quality (HQ = 1.83) and the Attractiveness (ATT = 1.75) are located in the above-average region, which indicates the overall impression of the R2S prototype is captivating and attractive. However, the prototype was only rated as average on the Pragmatic Quality (PQ = 0.33) dimension, which implies that there is room for improvement in terms of usefulness or usability, and indeed some usability issues were identified through annotating the researchers' prompt. Figure 6-7 shows the mean values of the word pairs that describe R2S, which is helpful to deeper understand the reasons behind the average score on each dimension. The result shows that R2S was perceived as a clearly structured, stylish, premium, creative, captivating, attractive and good system. The extreme negative side revealed that the main problems of the user experience stem from complexity and unpredictability.

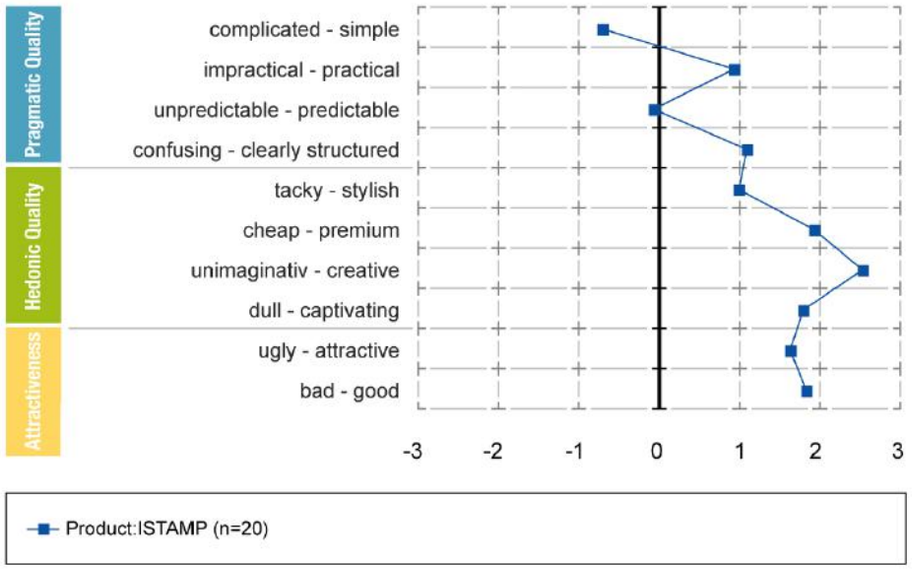


Figure 6-7 The description of word-pairs in the AttrakDiff-Short questionnaire

Since the video data identified the different ways of engagement between the low-care and high-care participants, we further analyzed their perceived user experience respectively. As shown in Figure 6-8, both of their ratings on the HQ and ATT dimensions were located in the above-average region, confirming that, both low-care and high-care participants thought the prototype was attractive and pleasing to use. Figure 6-9 illustrates the mean values of the word pairs rated by them respectively. We found the low-care participants rated slightly higher on almost every attribute on the HQ and ATT dimensions. In terms of Pragmatic Quality, the ratings of the low-care participants (above the average) were much higher than the high-care participants (below the average). From the description of the word pairs, we found that both low-care and high-care participants thought R2S was practical, but it was much more complicated, unpredictable and confusing to the high-care participants.

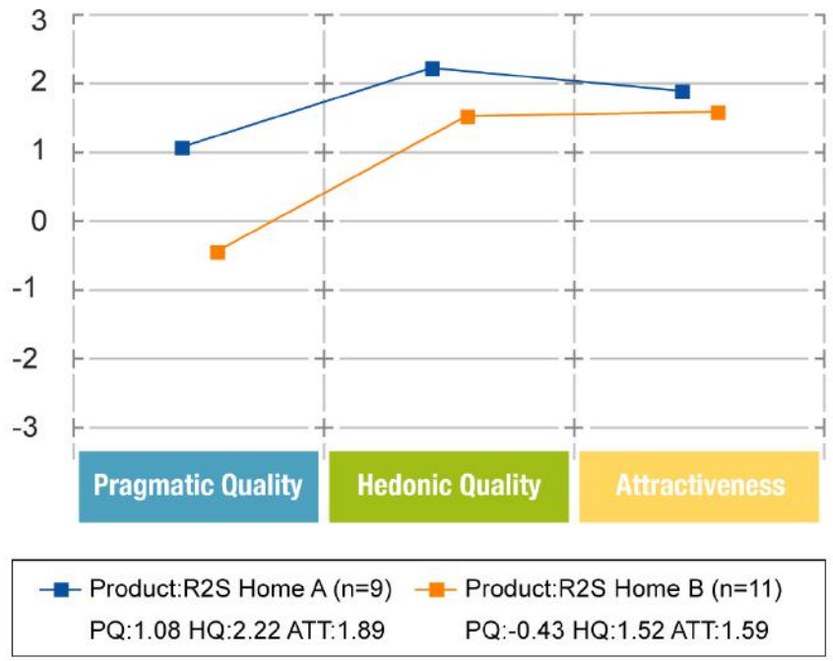


Figure 6-8 The average values of the three dimensions on the AttrakDiff-Short questionnaire rated by the participants from Home A and Home B respectively

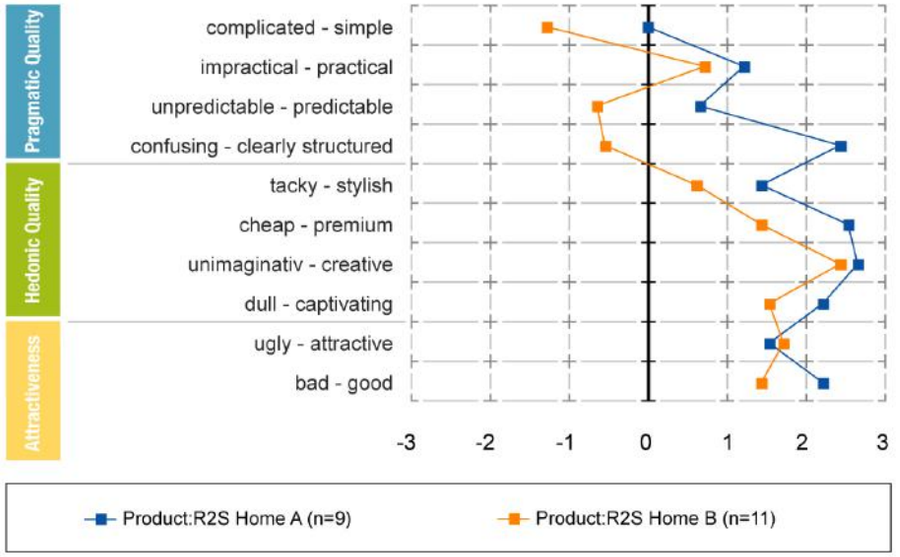


Figure 6-9 The description of word-pairs in the AttrakDiff-Short questionnaire rated by the participants from Home A and Home B respectively

- *Perceived closeness*

We collected the pre-trial and post-trial IOS scores from all the participants (N=20). The mean pre-trial IOS score was 4.85 out of 7(SD=1.59), which slightly rose to a mean of 4.9 (SD=1.67) after the trial. Since the IOS scores were not normally distributed (Shapiro Wilk test, $p < 0.05$), non-parametric statistical tests were applied. Wilcoxon signed-rank test (paired sample rank test) was used to compare the pre-trial and post-trial IOS scores. Although R2S was designed with the expectation to make the participants feel closer with each other, no significant difference was found ($Z=-0.25$, $p=0.8$).

6.5.3 Interview Results

- *Interview with residents*

According to the exit interviews, the participants primarily thought the design concept was very impressive. All of them expressed their appreciation for the integration of print and digital media. They thought the system lowered the technical threshold to get access to new information. "*If I want to see more about the news. I have to find out where it is, but I do not know, and this can make things easier.*" (P9, Group 4) "*If there is something you missed, you can always reverse, for the news yesterday, or the day before.*" (P6, Group3) Nine participants appreciated that R2S could lower the physical requirement to read. "*What I like is that I can read again because I had 2 times brain strokes, I can't read anymore.*" (P2, Group 1) "*Newspapers gave the background of the news, that is why I read, but for the news itself, I like to see it on the screen.*" (P3, Group1) Most of them were very optimistic about the future application in their public areas mainly because it provides updated information and flexible social choices. "*I will use it very frequently, not each time, but mostly, because many people usually come here (café) and get bored.*" (P6, Group3) "*Every morning, it will always be attractive. I will always look forward to it.*" (P15, Group 6) "*I can use it by myself and also for socializing.*" (P4, Group 2) P5 envisioned that R2S could be installed on every table in the cafe, while P15 (Group 6) thought it should be installed on half of the tables because it was important to provide choices for those who did not like new technologies. However, P2 held different views, as he felt bothered by the public environment. He preferred

to use the system in his room alone. P12 also expressed her concerns about the residents' acceptance of new technologies: "*It is good. But would it work? It is difficult in this home because many people here live in the past.*"

The participants' feedback on their user experience was in line with the result of the AttrakDiff-Short questionnaire. The overall user experience was reported to be very pleasing. The system features that were frequently complimented were summarized to be the stamp-like tangible tool, interesting interaction, freedom to select and control the media, news in the form of digital video, a better view to display information, the ability to provide updated topics, free of charge. The complexity reflected in the questionnaire was mainly corresponding to the participants' complaints about the video tutorial because it demonstrated too many details that were unnecessary to be understood by the participants. Therefore, some participants felt confused and overwhelmed to process the information in the beginning. However, in terms of use, most participants thought the system was very friendly to older users. "*We don't have a problem using it. Not complicated, I don't need to think too much.*" (P7, Group 3) The unpredictability reflected in the questionnaire was mainly because it was still a rather new invention to them, especially for some high-care participants. They claimed that they had enjoyed this activity, but they preferred to let the care workers operate to avoid making mistakes. Another important factor was related to their difficulties in searching IStickers. "*It is not always clear to find it. Not everybody here has good eyes. It should be more highlighted or something.*" (P12, Group 5) Four participants admitted that they would feel insecure without our prompt because they didn't know where IStickers were and how many they were. However, some low-care participants thought it was interesting to explore the content together because such experience never happened when they read newspapers before, but the experience would be better if the stickers could be clearer to find.

Regarding the social aspects, all the participants agreed that their communication could be enhanced via using R2S. "*Of course, it will trigger socializing. It is valuable to provide information for people to talk about.*" (P4, Group 2) "*We can discuss the topics and subjects with others, for social contact, it is very helpful.*" (P15, Group 6) Most participants agreed

that they were socially connected in such a shared experience. "*I felt involved in the group when we were using.*" (P7, Group 3). However, few of them could clearly describe the effects of R2S on their closeness feelings. Most participants claimed that they did not feel a big difference because this was their first time to use it and they only experienced it for a short period. This might explain why the pre-trial and post-trial scores of IOS questionnaire changed very little.

- *Interview with care workers*

According to the interviews, it had long been a problem for the care workers to encourage residents to come to their public areas. "*We tried to make the environment as attractive as possible, which is important for them, but they don't come very actively.*" (C3) According to the interviews, their daily work mainly includes searching potential themes, organizing corresponding activities and inviting residents to join, which was an effective way to attract the residents. However, the frequency of these activities was limited by the budget and time constraints. "*They (the management) don't pay a penny. People (residents) need to buy the card, the bingo card. We can buy some prizes with that money.*" (C1) "*We wish to present more interesting content, present more arranged programs by our professionals, but that is difficult. Time is Money.*" (C3)

After the demonstration, all the care workers could quickly understand the design concept from the video tutorial and smoothly tried the system without our prompt. They frequently mentioned that it was friendly and easy to use, even for older people. Two of them complained that very few new technologies could be involved in their work. Conventional devices such as computers, televisions and beamers were all the technologies that they could use for social interventions, but all these were mainly used in organized activities and operated by care workers. C4 mentioned that a 'magic table' was introduced in Home B recently. It was installed mainly for the residents with dementia to play projected tabletop games via gestures. Since the device was expensive and complicated, they had to lock it and use it with the guidance of professionals. Therefore, they were very enthusiastic about the idea of "freely turn the paper alive", which could not only create social opportunities in public areas but also provide new possibilities for their work because they

could customize their own applications by attaching the stickers to any paper interface. "*We have ideas of course, but we don't design new technologies. We are not really good at that. This is really something that we can use.*" (C4) Another important feature that they liked was the convenience to extend and the low cost to maintain the system. "*If we want more digital games for the magic table, we have to ask the developer, but they asked money for it. You need to pay 300 euros, which is expensive.*" (C4)

All the care workers were very optimistic about the future application. Their main concern was about residents' acceptance and interest. Since the system was already very easy to use, they suggested that more efforts could be made to attract the residents to take the first step. "*I am sure it is feasible. We will do this every day if they are interested in it.*" (C2) They thought the design should be introduced gradually because the residents would need some time to get used to it. "*At the beginning, I think one table is enough, but I can see this in the future, that you have the systems on several tables I think, some people will use together, some people watch on their own.*" (C1) The care workers did not doubt that R2S could have positive social effects, but other factors should also be taken into consideration. "*You have to make sure that the environment is good for showing.*" (C3) Since the system could be installed in various kinds of areas such as cafe, library, activity room and therapy room, C3 suggested that a mobile version could also be designed facilitate their care work with different purposes. Furthermore, they all believed that the social effects also highly depend on the displayed content. They agreed that augmenting the newspapers was an effective way to generate new information, and the residents liked to talk about the latest news, especially local news and sports news, but their professional experience indicated that watching things in the past would have a more profound social influence on their feelings such as the locations where they used to live and the special events when they were young. C4 suggested that special culture books and albums could be made and augmented by R2S. "*Sometimes people here are not quite good at expressing their feelings, but this could also be a way to talk about how they feel. That is something they are enthusiastic about. They are happy, maybe even without talking.*" (C4)

6.6 Summary of Takeaways

In this chapter, we present an evaluation of R2S. Supervised group trials in real-world settings were conducted to investigate the user engagement, user experience and explore the potential effects of R2S on residents' social behaviors and feelings. In this section, we first summarize and discuss the findings and results. Then, we further identify the key design implications that could contribute to designing IPDs in care environments.

The presented study showed that R2S was a success by our criteria in keeping the group members engaged and mainly actively engaged in content sharing and viewing. Although the engagement levels might be more or less influenced due to our supervision, especially the levels of the high-care participants, the vast majority of our assistances responded to the participants' obvious difficulties or active requests. Most high-care participants proved that they had the capability and interest to use R2S. According to the AttrakDiff-Short questionnaire, the high-care participants' rating of their perceived attractiveness was even higher than the low-care participants. However, the care workers mentioned that the high-care participants had been used to passively receiving information in such regular activities for many years, so it was reasonable that they needed more time to change this habit.

R2S allowed the participants to be engaged in their preferred way in most cases. R2S was originally designed as a content-based platform that was directly operated by one user and watched by others. We surprisingly found that the participants demonstrated various and dynamic usage patterns. Generally, each participant could freely choose their preferred ways to engage with R2S. However, we also noticed some 'engagement gaps' shortly before and after each display of the content. Due to the lack of considerations for the indirect users, they often showed nothing to do if they were unwilling or unable to join the operator, which resulted in a higher possibility to be disengaged.

The participants' perceived user experience of R2S was primarily positive. Many participants clearly expressed their willingness to use R2S in the future, but there was room for improvement in usability and reducing

uncertainty. The form of IStamp could be further refined with more ergonomic and psychological considerations for older users. The sensitivity of the system feedback could be configured to adapt to residents' use habits. The interactive areas on newspapers should be more highlighted for better recognition. The study showed that the negative ratings and comments were mainly related to the participants' confusions caused by their feelings of complexity and uncertainty. The complexity was reported by both low-care and high-care participants. As mentioned above, it was partly because the video tutorial demonstrated unnecessary information about the technology and content providers, which increased the participants' cognitive burden. Another important reason may relate to the restrictions of organized trial sessions. R2S was designed in a simple form to realize the basic function with easy interaction. More diverse functions and interactions were 'hidden' and designed in a hierarchy to avoid complexity. The richness needs to be gradually discovered in residents' daily use. Therefore, it was challenging for the participants to experience all the functions in their first trial and in such a short period. According to their feedback afterwards, the complexity reflected in this study was unlikely to be a problem in their actual daily use. The uncertainty was mainly reported by the high-care participants. Their effort to use seemed to be highly increased due to the lack of instructions about the locations of the interactive areas and the content to be displayed, which lowered their motivation to explore the potential content actively. Although some low-care participants thought it was interesting to search for information, we believe the system needs to be improved to be easily used by more residents, especially those in lower physical or mental conditions.

R2S showed a lot of potentials to catalyze social interactions between the group members. Digital videos seemed to be a better form to trigger, mediate and sustain conversations than other media forms we prepared. Furthermore, the participants showed many kinds of social interactions, which was also beyond our expectations. R2S was originally designed to trigger residents' conversations via one-to-many or one-to-one sharing. In this study, we noticed using R2S could also trigger many-to-one or even many-to-many sharing, and the interactions could be maintained via various social interaction patterns such as collaborative exploration, social learning, watching together, etc. Generally, the findings showed that the participants' social interaction levels were positively related to their engagement levels

with R2S. However, we also noticed that the participants' unfamiliarity could lead to highly-focused use, which might reduce the social opportunities. In addition, we found the social effects of R2S tended to decline in larger groups because they had more non-operators who were easier to be passively engaged or disengaged.

Although R2S was designed mainly focused on enhancing nursing home residents' social interaction, we assumed that it might also influence their social feelings. However, neither the questionnaires nor the interviews in this study reported significant differences in their perceived closeness. It was partly because of the limitations of the measurement. The social effects on feelings should not be confined to closeness. Visser et al. (2011) found that typical social feelings like social connectedness were often described along with many other dimensions such as perceived contact quality and shared understanding, the improvement of which were also mentioned in our interviews. However, given the participants' difficulties in filling out the standard questionnaires, we only measured the participants' perceived closeness in this study, which proved to be insufficient to describe the subjective social impacts. Apart from the methodology, the interviews indicated that their closeness of feelings could be influenced by many other factors such as the composition of the group, their prior relationships, personal interests and the displayed content. Therefore, we could only initially conclude that, with the selected news content, the effects of R2S on the participants' perceived closeness was very limited after short periods of use, which needs to be further investigated with various content, longer experience and more comprehensive measurements.

6.7 Design Implications

Apart from some basic design principles that fit most technologies for older people, such as simple and friendly form, effortless interaction, we identified some key design implications for the following trials as follows:

- *Customizable content*

The content was not the focus of the present study, but it plays a fundamental role in designing display systems for social interaction. Although the content selection in this study followed our previous findings in Chapter 4, we were frequently asked by the participants whether we had prepared some content related to their personal interests or backgrounds. They envisioned the public display as a platform of self-disclosure. Besides, the flexibility and adaptiveness of IStickers were highly appreciated by the care workers. They proposed various potential content that could be displayed in different scenarios. Therefore, given the complexity and diversity of the residents' backgrounds and situations, the public displays in care environments should not only show general predetermined content from service providers or social media. The content should also be customizable by the care workers or residents themselves. Furthermore, updating and maintaining the customized content should be quick, effortless and cheap.

- *Horizontal and vertical display*

R2S was featured by the combination of a horizontal display and a vertical display, which was proved to be a promising form of tabletop displays to promote social interaction in nursing homes. Such display form was in line with the transactional model of communication (Barnlund, 2008). The horizontal displays serve as private cues. They could be designed in a smaller size to show potential content mainly for individual or pair residents to explore, preview and select content. The vertical displays serve as public cues that could be designed in a larger size to 'broadcast' the shared content to the social group. Given our participants' acceptance and ability to use new technologies, the newspaper played the role of a horizontal display in this case. Flipping pages was a much more intuitive way for them to explore

information, but it also had many limitations. For example, conventional print media products cannot provide active feedback to guide senior users. However, the care workers mentioned that the residents' capability was improving with the younger generations moving in, which provides more possibilities to design technologies in such display form in the future.

- *Support continuous parallel use*

R2S allowed the participants to be engaged in their preferred way and support parallel use to some extent. However, like most conventional interactive public displays, the design of R2S was centered around the operators who directly determined the content to be displayed. Most non-operators mainly played the role of viewers. Due to the lack of considerations for the non-operators, the system was configured to only display a standby image when nothing was shared by the operators to avoid intrusiveness. During this gap, many of them seemed to be impatient and tended to be distracted, which lowered their engagement levels and thus reduced social opportunities. Therefore, the interactive public tabletop displays in nursing homes should be designed not only for the operators but also for the non-operators. The system needs to be able to support their continuous parallel use to avoid the 'engagement gap'.

- *Design for diverse social interaction*

We annotated the observed social interaction into four levels. Most existing commercial socio-technical systems were designed to promote high-level social interactions such as collaborations and active conversations, which was also what we aimed to achieve when designing R2S. However, the result and findings of this study indicated that different participants could benefit from different levels of social interaction. For example, some residents who suffered from the degradations of their communicational functions might feel more relaxed and connected in mild, mediated or passive communications than intensive, direct and active conversations. Some participants even appreciated that R2S could be used individually so that they would not feel embarrassed in public areas. Therefore, the sociability of public display systems should not only be measured by the levels of the triggered social interaction but the

ability to provide opportunities for diverse social interactions. If we compare the socio-technical systems to sports, what we need to design for public care environments is basketball that can be played alone, 1 on 1, 3 on 3 or 5 on 5, rather than tennis that usually requires partners to play with.

Chapter 7.
Open Field Trial of R2S

7.1 Introduction

In the supervised field trial presented in Chapter 6, we mainly investigated how the residents would engage with R2S, how R2S would potentially influence their social interaction, and how the residents would perceive their user experience and feelings of closeness. Since interactive public displays are closely tied to their environments, people in the environment, and the situations to use, we believe the ultimate evaluation of IPD systems should be conducted in an open field trial without external assistance. Furthermore, the social aspects can be better investigated in users' daily lives than in a laboratory or any other simulated context. As such, the supervised field trial mainly served as a pre-evaluation and preparation for the open field trial. The derived design implications and uncovered usability issues contributed to a further refinement of the system. In this chapter, we first describe the redesigned version of R2S based on the insights from Chapter 6. Then, we present an open field trial of R2S. Generally, the field trial was carried out to investigate the residents' usage of R2S in their daily life, the impact of R2S on residents' daily behaviors, the residents' perceived user experience and social feelings related to R2S. Based on the result, we conceptualize a framework of typical user types and interactions with tabletop IPD systems in nursing homes. The social roles of IPDs in nursing home residents' daily lives are discussed. At the end of this chapter, we illustrate the implications of the design and deployment of IPDs for social interaction among nursing home residents.

7.2 System Upgrades of R2S

- *The R2S App*

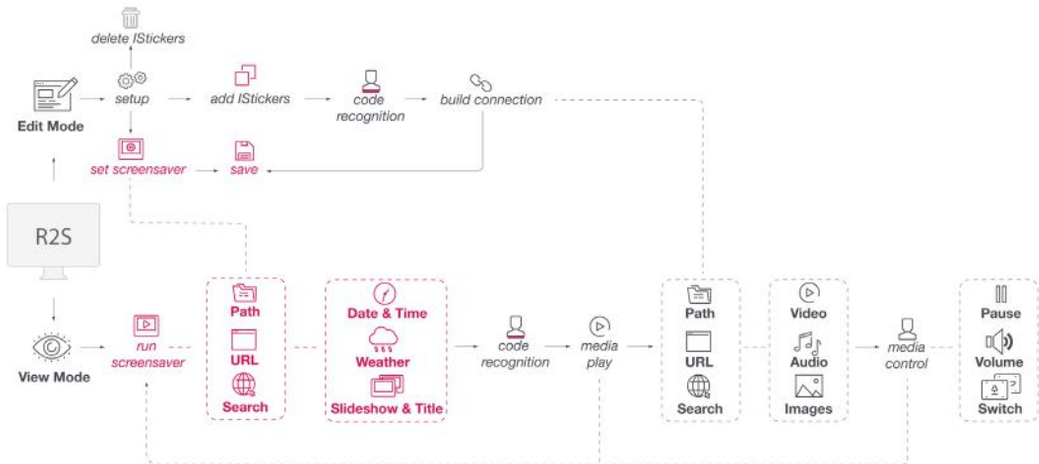


Figure 7-1 The structure of the R2S application. A screensaver module (the red part) was added in both the Edit Mode and the View Mode.

The supervised field trial in Chapter 6 uncovered an engagement gap for the passive users when the R2S application was in a 'standby' state, which might decrease their engagement and social interaction level. Therefore, we mainly upgraded the R2S application by adding a screensaver module in both the Edit Mode and the View Mode (Figure 7-1). In the upgraded Edit Mode, the caregivers could not only edit IStickers but also set the screensavers to be displayed in the View Mode. The screensaver can provide an overview of the augmented news prepared by the caregivers. They can be edited via uploading images from a file path, inputting texts or related Internet links. Once the R2S application is switched to the View Mode, the system is put on standby and automatically runs a slideshow in an ambient way. Besides the preset images and texts, the screensaver also includes the real-time date, time, temperature and weather forecast. Additionally, to support the following open field trial, we further developed the software application into an Android App to realize all above functionalities (Figure 7-2).

Figure 7-2 The fully functional R2S app for Android systems

- *Physical interfaces*

Although the main physical interface was designed in the form of a stamp to reduce older adults' technical barriers, we still found that some participants were cautious to touch IStamp, especially the high care residents. It seemed that they were intimidated by "the hi-tech feelings" brought by the lighting within IStamp and its white resin material. However, the caregivers claimed that the lighting feedback was very helpful for their editing. Therefore, we removed the lighting effects to invite users but kept the lighting feedback when IStamp successfully detected IStickers. To avoid intimidating the residents, we limited the luminous area to the bottom of the stamp (Figure 7-3). We also updated the material of IStamp by referring to some media products that were familiar to older people such as vintage radio players (Figure 7-3). Regarding IStickers, we followed some participants' suggestions to highlight the IStcikers by using eye-catching colors and glossy material.

Figure 7-3 The upgraded IStamp and IStickers

- *Digital interfaces*

Figure 7-4 shows the upgraded version of the main digital interface for the nursing home residents in the View Mode. As mentioned above, the R2S app automatically runs a slideshow once it is switched to the View Mode. The slideshow image mainly consists of the thumbnail photo and the headline of the news. We also added some secondary information based on the participants' feedback in the supervised field trial. A logo of the news source is located in the upper left corner to remind the residents of the relationship between the newspaper and the display. The page number of the displayed news is shown above the headline to facilitate the residents to read the article or find the corresponding ISticker if they are interested. Below the headline, there is an instruction to motivate the residents to use the stamp to watch more dynamic content about the news. Additionally, we designed a semi-transparent widget floating on the upper right corner to display real-time information, including time, date, temperature, and weather, which is very useful for the residents during their daily activities in public spaces.

Figure 7-4 The main digital interface in the View Mode

- *Other upgrades*

Figure 7-5 The digital and physical instructions of R2S

Given the lack of external assistance from the designers or caregivers in the open field trial, we added digital and physical instructions to ensure that the residents could quickly learn how to use R2S. As shown in Figure 7-5, the digital instruction shows the main interaction of stamping on the stickers. It is displayed at intervals as one of the screensavers. The physical instruction is printed on a foamboard nearby the screen. It demonstrates more ways of using IStamp.

7.3 Study Objectives

Since R2S has been further refined and upgraded to a fully functional system, an open field trial was carried out to explore the social impact of R2S on the residents' daily life. The objectives of this study were mainly to investigate the following three questions:

Q1. To what extent and how would R2S impact the residents' daily behaviors?

Q2. To what extent and how would the residents use R2S in their daily life?

Q3. How would the residents perceive their user experience and social feelings related to R2S?

7.4 Study Setup

This study was carried out in a nursing home (Home A in Chapter 6) located in Eindhoven. This nursing home was affiliated to a big corporate-owned care organization that established more than twenty nursing homes distributed in this city. They were similar in terms of environments, facilities, services and policies.

As shown in Figure 7-6, the nursing home was built into a complex consisting of three residential buildings with various supporting facilities. The residential buildings contained about four hundred single-bedroom apartments in total. At the time of this study, all the apartments were rented out, and new applicants were waiting for their turn to move in. The outdoor facilities mainly included a parking space in a closed area, a garden with seating areas and a bocce court. The indoor facilities consist of a central meeting room (hereafter referred to as CM) and multiple secondary areas, including a pedicure room, a restaurant, a billiards room and a mini-supermarket. The residential buildings and common areas were connected via internal corridors so that all residents could get access to these facilities.

Figure 7-6 An aerial view of the nursing home

This nursing home provided care services in three levels: "Daytime activities" were provided for most residents with mild dementia or physical problems to remain independent for as long as possible. On some floors, "Living with care" was an option of 24-hour care for the residents who could not live independently. "Small-scale living" was only provided in a separate area for the residents in the later stages of dementia. This study mainly focused on the residents covered by "Daytime activities" because they were the primary users of the public facilities.

CM was chosen to be the area to deploy R2S. It was mainly because CM was the primary area for residents' self-entertainment, spontaneous or organized social activities (Figure 7-7). Furthermore, our case study of OutLook indicated that socio-technical systems in care environments should be applied where most residents stay rather than pass. As shown in Figure 7-6, CM was located between the garden and parking space, surrounded by the three residential buildings. People could enter CM through one entrance (Entrance A) that was connected to the lobby and residential building #1, or another entrance (Entrance B) that led to the secondary facilities and two

other residential buildings. CM was built in the form of a café offering snack and beverage services for the residents, caregivers and visitors from 8:00 AM to 5:00 PM. A flat-screen television was mounted on the wall in the back, but it was rarely turned on. Normally, free coffee drinks were offered in CM from 2:00 PM to 4:00 PM to attract more residents and promote their social interaction. On some specific days, CM was also where various kinds of social programs were organized.

Figure 7-7 A photo of the central meeting room (CM)

7.5 Study Design

To answer the three questions (Section 7.3), we aimed to identify the residents' behavior changes brought by R2S in their daily lives. However, given the public nature of the setting, and we did not plan to recruit any participants beforehand, the residents' behavior in CM could be influenced by many other factors. Although we tried to maintain the consistency and continuity of this study, it was not realistic to control all the relevant variables, which means it was difficult to conduct conventional experimental research. For this reason, instead of controlling the independent variables, we aimed to investigate the impacts of R2S by illustrating and comparing residents' behaviors in different conditions. We adopted a quasi-experimental design with descriptive research methods that utilized elements from both quantitative and qualitative data. As shown in Figure 7-8, this study mainly consists of four phases. Since the residents' personal and organized schedules were weekly based, each period of the study lasted for seven days as a unit.

Figure 7-8 The procedure of the open field trial

- *Phase 1 Pre-Deployment*

In the first phase of one week, we used structured observations with the camera to collect residents' current behavioral data in CM before the deployment of R2S. The observation lasted for 2 hours from 2:00 PM to 4:00 PM every day because as mentioned above, it was the period when most of the residents came to CM for social contacts. The purpose of Phase 1 was to further understand residents' personal daily routines and social habits in CM. The findings could guide us to distinguish the several typical conditions that would be set in the deployment phase. Residents' behaviors in Phase 1 also served as a baseline to compare the differences between the conditions.

- *Phase 2 Introduction*

In the second phase, an introduction week was organized to promote R2S to as many residents as possible. The main purpose of this phase was to help the residents be aware of the presence of R2S in CM, briefly understand its concept and ways of use. Our case study of OutLook indicated that such introduction activity was very important for nursing home residents to better accept and use novel technologies before actual deployment. Another purpose was to test the usability and stability of R2S for long-term use in the following phases.

With the assistance of 2 caregivers, R2S was installed on the table next to the public television in CM from 2:00 PM to 4:00 PM every day. The television was used as the digital display of R2S to attract the residents in CM (Figure 7-9). To inform the residents who do not come out frequently, we sent 400 printed invitations (Appendix C) to their mailboxes at the beginning of Phase 1, and two posters were attached to the billboards at the entrance and hallway to promote the activity. Upon arrival, the participants were welcomed with drinks and snacks ordered by two research assistants. The introduction sessions were started with casual conversations to collect the participants' basic information, including name (optional), gender, room number (optional), daily routines, etc. Then, the research assistants introduced R2S by demonstration and oral explanation. The participants were encouraged to use R2S independently after the introduction. In the end, short interviews with open questions were conducted to collect their initial feedback on user experience and usability. Besides, to identify the conditions to be set for the following phases, the introduction week was also the period when we initially analyzed the observational data in Phase 1.

Figure 7-9 R2S was deployed on the Table with the public television for introduction week.

- *Phase 3 Deployment*

To better explore the impact of R2S in the field, we deployed a single unit of R2S in different conditions.

Although R2S was designed as a system with many units that could be installed on multiple tables, we decided to deploy only one unit in CM based on the following considerations: 1) All the units of R2S were designed to be identical and independent. 2) The caregivers pointed out that large-scale application from the beginning would surely lead to residents' dissatisfaction because they were very vulnerable to radical changes in their surroundings. They had received many complaints just because they changed some part of the wallpaper in CM. 3) According to the feedback in the design process (Chapter 5), even though R2S could be accepted and used by many residents, some tables should remain unchanged for those who do not like technology. 4) From the perspective of research, deploying a single unit would be clearer to distinguish the impact of R2S and compare the differences between the table with and without R2S.

The conditions were set by deploying R2S on different tables. Our prior investigations in Phase 1 revealed the fact that almost all the residents' activities in CM were centered around the tables. Although these tables were similar physically, they had been gradually labelled as completely different social platforms after the residents' use for years. Therefore, in Phase 3, we successively deployed R2S on three typical tables with different social labels, each of which represented one condition and lasted for one week. The three conditions were mainly distinguished from the observational data in Phase 1.

In the period of each condition, R2S was installed in the evening before the first day. One research assistant was recruited to augment 8 articles from the latest local newspaper every morning. The principle to select the articles was based on our context study in Chapter 4. The system was configured to display the latest related video searched from YouTube once the articles were "stamped" by users. R2S was set up and turned on before 1:30 PM and kept running until 4:30 PM every afternoon. The same structured observations as Phase 1 were adopted from 2:00 PM to 4:00 PM in Phase 3.

- *Phase 4 Post Deployment*

To avoid interrupting the residents' natural behavior during the deployment, Phase 4 was designed to collect the residents' subjective data. Since most residents had stable daily routines and their schedules were mainly weekly based, within a week after Phase 3, two research assistants visited CM every afternoon to invite the people who were involved in this study or make appointments. Semi-structured interviews and questionnaires were used to investigate their usage, user experience and social feelings. Until the end of phase 4, R2S was remained on the table to help the participants recall their related experiences.

7.6 Measurement

Table 7-1 briefly shows the measurement and data in response to the three questions of our study objective. They are explained further as follows:

Objective	Measurement	Data
Q1	*number of residents recorded at different tables*	*video records and field notes*
	residents' time spent at different tables	*video records and field notes*
Q2	*duration of using IStamp*	*system logs*
	frequency of each operation with IStamp	*system logs*
	preferred time period of using IStamp	*system logs*
	use patterns and habits	*interview, video records and field notes*
Q3	*UEQ-S*	*questionnaire*
	questions from ABCCT	*interview*

Table 7-1 An overview of the measurement and data in response to each study objective

- *Impact on residents' daily behaviors (Q1)*

The impact of R2S on residents' daily behaviors was investigated mainly through observational data, including video records and field journals. The video records allowed us to identify possible quantitative changes in residents' daily behaviors between the conditions. The field journals could guide us to further analyze the video records and qualitatively illustrate the residents' reactions. In this study, the quantitative changes between different conditions could be measured by calculating the total number of residents and their time spent at the tables in the observation area.

- *Usage of R2S (Q2)*

The residents' usage of R2S was investigated mainly through the systems logs and interviews. The upgraded R2S application was configured to record direct user interaction with IStamp (e.g., stamp, pause, volume control) and related information (e.g., date, time, the received RFID codes, URL of the played videos). With the system logs, the total duration of using IStamp each day could be calculated to compare how the residents' time spent on directly using R2S changed in different conditions. The frequency of each interaction with IStamp each day could be calculated to explore the possible changes in their use patterns. The residents' preferred time period of using IStamp in different conditions could also be investigated by calculating the accumulated frequency of using IStamp in each period of two hours. Since not all the residents were engaged with R2S via directly using IStamp, their general use patterns and habits were investigated through the post-trial interviews.

- *User experience (Q3)*

The participants' perceived user experience was measured with the short version of the User Experience Questionnaire (UEQ-S, Appendix D). UEQ is a standard instrument that has been widely used to measure users' subjective impressions towards the user experience of any interactive products (Laugwitz et al., 2008).

The full version of UEQ consists of 26 pairs of adjectives that are grouped in six scales (Attractiveness; Perspicuity; Efficiency; Dependability;

Stimulation; Novelty). Participants rate each item on a 7-point Likert scale. Although the UEQ has been recognized as a simple and efficient tool and it is usually assumed to be completed within five minutes, a short version was developed and validated in response to numerous researchers' requests because a full UEQ is considered to be too time-consuming in many cases (Schrepp et al., 2017). Since our experience in Chapter 6 indicated that filling out long questionnaires was challenging for many nursing home residents, and the participants had been asked many questions beforehand, we adopted the UEQ-S in this study to ensure the completion and effectiveness. The short version has eight items and concentrates on the measurement of two meta-dimensions: pragmatic and hedonic quality (four items each).

In addition, compared with AttrakDiff that we used in Chapter 6, both UEQ and AttrakDiff were among the most recognized questionnaires for user experience evaluation (Díaz-Oreiro et al., 2019). The study conducted by Laugwitz et al (2008) indicated that the similar dimensions of UEQ and AttrakDiff were highly correlated. Since UEQ-S was a newly-developed questionnaire and its analysis tool could provide more detailed information, we chose to use UEQ-S in this study. Furthermore, a more recent study found that UEQ could better detect the deterioration of user experience over time and indicate more future improvements (Nakamura et al., 2021). The dimensions and structure of UEQ were also easier to understand than AttrakDiff (Nakamura et al., 2021), which might explain that the usage of the UEQ questionnaire has far surpassed AttrakDiff since 2017 (Díaz-Oreiro et al., 2019).

- *Social feelings (Q3)*

The residents' social feelings related to using R2S were assessed via the post-trial interviews. The questions were mainly adapted from the Affective Benefits and Costs of Communication Technologies (ABCCT) questionnaire. ABCCT questionnaire was developed to assess the affective benefits and costs of novel socio-technical systems (Yarosh et al., 2014).

Our experience from Chapter 6 indicated that the social impact of technologies on residents' feelings should be investigated from multiple perspectives. However, most standard questionnaires only specialized

in one particular dimension and overlook the negative sides, such as the Quality of Relationships Inventory (Pierce, 1994), the Social Connectedness Questionnaire (Lee et al., 2001), and the Inclusion of Others in the Self used in Chapter 6. Furthermore, the majority of these instruments ask subjects' social connectedness or closeness in general without addressing the targeted technology in question, which was easy to confuse participants (Yarosh et al., 2014).

To address the above mentioned, ABCCT was developed and validated with seven scales consisting of four affective benefits (Emotional Expressiveness; Engagement & Playfulness; Presence-In-Absence; Opportunity for Social Support) and three affective costs (Feeling Obligated; Unmet Expectations; Threat to Privacy). However, it requires the participants to answer 26 questions by a 5-point Likert scale, which would be a challenging task for most older participants. Therefore, we selected some typical questions in each scale of ACCT and revised them into interview questions according to our design and research context (Appendix E). The participants were free to skip or refuse to answer any item if they felt uncomfortable.

7.7 Data Collection

To answer the three questions in Section 7.3, we employed several methods to collect the objective (video records and system data logs) and subjective data (interviews and questionnaires). Due to the lack of references from previous work that fit our research objectives and context, one manager and two caregivers of the nursing home were involved in developing feasible methods of data collection. Before the deployment, the proposed method was drafted as a data management plan that was reviewed and approved by the GDPR committee (General Data Protection Regulation) of the nursing home.

7.7.1 Objective Data Collection

To collect objective data, we tried to explore a method to collect the residents' behavioral data without the invasion of their privacy. Since we intended to observe not only one table but also the nearby environment, and CM was one of the busiest areas where people from various backgrounds come and go, the conventional method of manually talking field notes was challenging to capture the scene that was full of liveness and dynamism, particularly when components occur simultaneously. It was also very challenging to make predefined coding schemes due to the complexity and unpredictability. Besides, although CM was an open space for the residents or visitors, direct video recording was not allowed by the regulations. Therefore, we integrated manual and video recording.

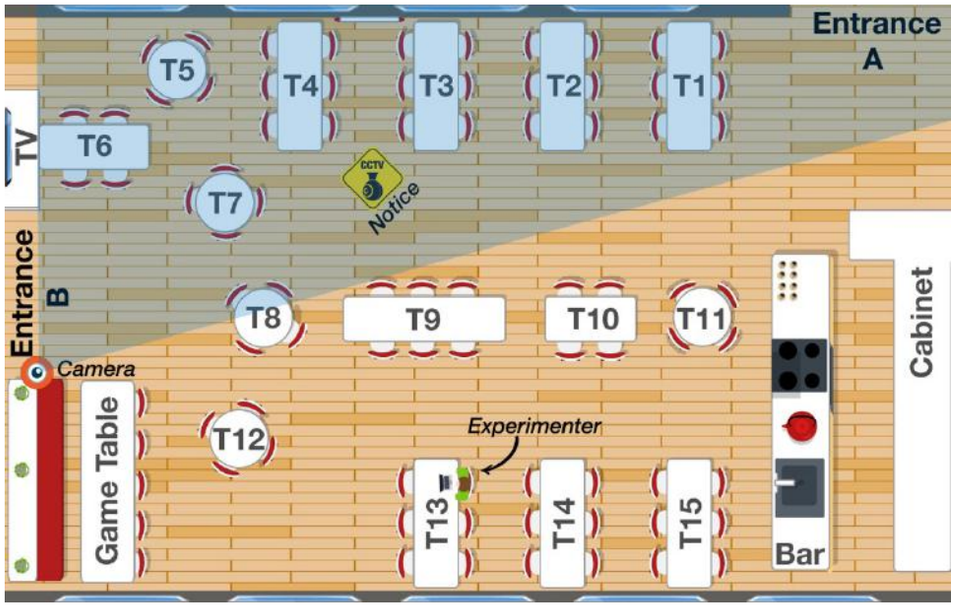


Figure 7-10 The settings in the central meeting room

As shown in Figure 7-10, the residents' behavioral data were mainly collected by a web camera. It mainly recorded the half area of CM containing the table from T1 to T7. As required by the manager, the camera was installed on a shelf at Entrance B, at a distance from the tables. The captured image was

transferred directly to the laptop of the experimenter who sat at T13 in the other half of CM. Before saving, the received videos were specially processed in real-time so that the residents' identities could not be recognized (Figure 7-11). The video records were saved every 15 minutes to avoid unexpected system crashes during processing. Besides, we put a notice in the targeted area to inform the people of the recording time/area, reasons for recording and our measures to protect their privacy. The residents were welcome to come as usual. If they didn't want to be recorded, they could choose to go to the other half area. Furthermore, to make up for the limitations of the video recording, journaling was also adopted by the on-site experimenter to record the physical characteristics of typical subjects, their special behaviors and incidents that took place in the observed area. Apart from the behavioral data, the R2S app was configured to collect the system log data when the residents directly used IStamp.

Figure 7-11 The collected video data were specially processed in real time.

7.7.2 Subjective Data Collection

Group	Joined Introduction	Used R2S	Questions & Qestionnaire
1	*Yes*	*Yes*	*frequency, patterns, and scenarios of use, related factors, influence on their daily activities, ABCCT questions, and UEQ-S*
2	*No*	*Yes*	*same questions with Group 1, how they noticed and learned to use, and UEQ-S*
3	*Yes*	*No*	*understand R2S or not, why they didn't use*

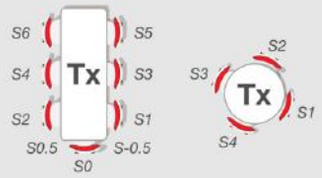
Table 7-2 The participants were classified into 3 groups based on their involvement in this study

Subjective data were collected via interviews and questionnaires after the deployment to avoid interruption. Since we did not deliberately recruit any residents during the deployment, the participants were identified under the guidance of the on-site experimenter and journals in Phase 4. Given many participants had reading or writing difficulties, consent was given orally before each session. The participants were classified into 3 groups according to their degrees of involvement (Table 7-2). The participants in Group1 joined the introduction week and used R2S during the deployment. The participants in Group 2 didn't join the introduction but used R2S afterwards. The participants in Group 3 joined the introduction but did not use R2S since then. We prepared different sets of questions for different groups. The questions for Group 1 mainly consist of two parts. Firstly, the participants were asked to simply describe their frequency of use, use patterns, scenarios, the factors that they liked and disliked, the influence of R2S on their daily activities. Secondly, structured questions from the ABCCT (Affective Benefits and Costs of Communication Technologies) questionnaire were used to further understand their related social feelings. The questions for Group 2 covered all the questions for Group 1. More questions were added to ask how they noticed and learned to use R2S. The questions for Group 3 were much simpler. We first checked if the participants could fully understand R2S from the introduction week. Then, we asked their reasons for not using and suggestions for improvement. The interviews were recorded with their permission. After the interviews, the participants of Group 1 and Group 2 were asked to fill out UEQ-S to assess their user experience (Laugwitz et al., 2008). Upon completion, each participant was given a gift coupon (10 euros).

7.8 Data Analysis

Location Codes:
EA = Entrance A
EB = Entrance B
Tx= Table No. x
NTx = Path Near Table No. x
Sx = Seat No.x

Position Codes:
W = Walking
WR / WW = Walking with Rollator / Wheelchair
ST = Standing
STR = Standing with Rollator
SI = Sitting in Chair
SIR = Sitting on Rollator



ID	Subject	Gender	Star Time	End Time	Location	Behavior	Position	Notes
1	Berry	M	14:10	none	EA	Enter	W	
			14:10	14:13	NT3	Social	ST	
			14:13	14:50	T3 S2	Social	SI	
			14:50	none	EB	Leave	W	
2	Wiki	F	14:20	none	EB	Enter	WR	
			14:20	14:25	T4 S1	Unsocial	SI	
			14:25	none	EB	Leave	WR	

Figure 7-12 An example of the datasheet to transcribe the video data

The analysis of the observational data consisted of two stages. The first stage was to transcribe the video records into a datasheet in Excel. We used scan sampling to rapidly record the behavior of all the individuals shown in the observation area at a regular interval of 1 minute (Hepworth & Hamilton, 2001). The format of the datasheet was developed based on our assumptions and previous studies (Chapter 3). As shown in Figure 7-12, the datasheet recorded subjects' identity, gender, time, behavior, location, position and additional descriptions. Since the residents' faces were blurred in the raw data, the subjects' identities were mainly recorded with a short description of their characteristics such as appearance, gait and dressing style. The subjects who were frequently observed were distinguished by the field experimenter and assigned pseudonyms. The subjects' behaviors were recorded in two forms: events and states. An event is a behavior pattern of short duration, such as entering/leaving the recorded area, which was recorded as points in time. A State is a behavior pattern of long duration, such as talking or gazing at someone or something, which was recorded with their start points and end points in time. Instead of transcribing subjects' every detailed behavior, we generally summarized their state to be social or unsocial. The unsocial state means the subject stays alone or sits far from others at one table without any communication. The social state covers the spectrum from low to high

degrees of social interaction when the subjects stay with others. We did not further divide the social state into detailed behaviors because our previous studies indicated that nursing home residents could benefit from different levels of social interaction according to their physical, mental or emotional conditions, which was unnecessary to be specially distinguished in this study. The subjects' location and position were recorded via codes for rapid transcription. As shown in Figure 7-12, the recorded area was primarily divided into several subareas based on the tables. If the subjects sat at one table, we further coded their seats for later tracking. Additional descriptions could be added after each record if some special situations or behaviors were observed. With the completed datasheet, the number of the residents who showed up every day and their time spent at each table could be calculated. In the second stage, the video records were imported into Nvivo. They were further annotated according to the filed journals and the additional descriptions in the datasheet. The annotations were then qualitatively analyzed using the thematic analysis technique (Braun & Clarke, 2012).

Date	Star Time	End Time	Operation	Title of the Content
07/ 30	14:08	none	Stamp	*Quote bezorgt de nieuwe Quote 500 bij Jitse Groen*
07/ 30	14:09	none	Pause	*Quote bezorgt de nieuwe Quote 500 bij Jitse Groen*
07/ 30	14:09	14:10	Volume	*Quote bezorgt de nieuwe Quote 500 bij Jitse Groen*
07/ 30	14:16	none	Stamp	*Zeearend Beuven Strabrechtse Heide UHD 4K Natuurkanaal*
07/ 30	14:16	14:17	Volume	*Zeearend Beuven Strabrechtse Heide UHD 4K Natuurkanaal*
07/ 30	14:17	none	Pause	*Zeearend Beuven Strabrechtse Heide UHD 4K Natuurkanaal*
07/ 30	14:19	none	Stamp	*Zeearend Beuven Strabrechtse Heide UHD 4K Natuurkanaal*
07/ 30	14:32	none	Stamp	*Van Bommel Keihard Voor Eigen PSV*
07/ 30	14:33	none	Pause	*Van Bommel Keihard Voor Eigen PSV*

Figure 7-13 An example of the datasheet to transcribe the system log

Similar to the analysis of the video records, the system logs were generated into txt files and transcribed into a datasheet in Excel (Figure 7-13). The datasheet contained the start/end time of each operation, the type of the operation, the title of the displayed content. With the completed datasheet, the duration of each operation could be added up to calculate the total usage time of IStamp. The number of each type of operation could be counted to calculate the frequency of the detailed interaction with IStamp. To explore the residents' preferred period of using IStamp, we used heatmaps to

demonstrate the accumulated frequency of using IStamp in different time slots in two hours.

The participants' ratings of the UEQ-S questionnaire were entered into its official data analysis tool in Excel (Schrepp et al., 2015). The tool could automatically calculate the means of the two meta-dimensions: pragmatic and hedonic quality. It also provides a comparison between the scale means and a benchmark data set.

The interview records were transcribed and imported to NVivo. The participants' descriptions related to their use patterns and habits were manually coded and classified using thematic techniques (Welsh, 2002). Their answers to the ABCCT questions were also coded and categorized based on the seven scales of four affective benefits and three affective costs.

7.9 Findings before Deployment

7.9.1 Feedback from Introduction Week

According to our records, twenty-seven residents in total joined the introduction week. Although we sent four hundred invitations, only three residents came to T6 with the invitations. It seemed that the activity to introduce new technologies was much less attractive than their regular familiar programs such as games and performances. One lady came because she was interested in technology. Another lady came out of curiosity and she did not like to stay in her room alone. However, she admitted that she feared using new technologies as many other residents did. A man came with his family because they mentioned this activity in their family visit last week, and he thought technology was a good way to understand his children and grandchildren better. Six residents came to participate mainly because they were attracted by the content displayed on the television when they passed the nearby area. The rest eighteen residents were invited mainly by the research assistants or encouraged by the caregivers in CM. Seven of them belonged to the social group at T1. Six residents belonged to the group at T3, and the rest five residents were in the social group out of the recording area. Although the introduction week attracted much fewer residents who

rarely came to CM than we had expected, most residents who occasionally or frequently came could be more or less informed of the concept of R2S via our demonstrations, conversations with their peers or their observations. During this period, no obvious usability issues were reported by the residents. The performance, reliability, and stability of R2S were tested to be capable of long-term field deployment.

7.9.2 Condition Identification

The observational data in Phase 1 was initially analyzed in Phase 2 to provide an empirical basis for the deployment in Phase 3. Compared with our prior investigations, the camera and notice had very little influence on residents' daily activities in CM. The majority of them chose to stay where they used to be even after noticing it. As shown in Figure 7-14, the line chart indicates the total number of residents recorded in CM kept very steady. On average, there were about 25 residents came to this area every day, many of whom could be recognized by the field experimenter because they were frequently recorded in the journals. The stacked columns demonstrate the number of the residents and the amount of social time that they spent at each table. We found that the residents were inequality distributed at the tables, and such distribution patterns remained steady every day, which resulted in a significant difference in the social time between the tables. The finding of Phase 1 shows that many residents kept very regular daily routines in CM, and the tables, although looked similar, served different kinds of residents with different social purposes according to some unspoken agreement. Therefore, we assumed that the impact of R2S might also be different if R2S was installed on different kinds of tables. Based on the observational data, we identified three kinds of tables.

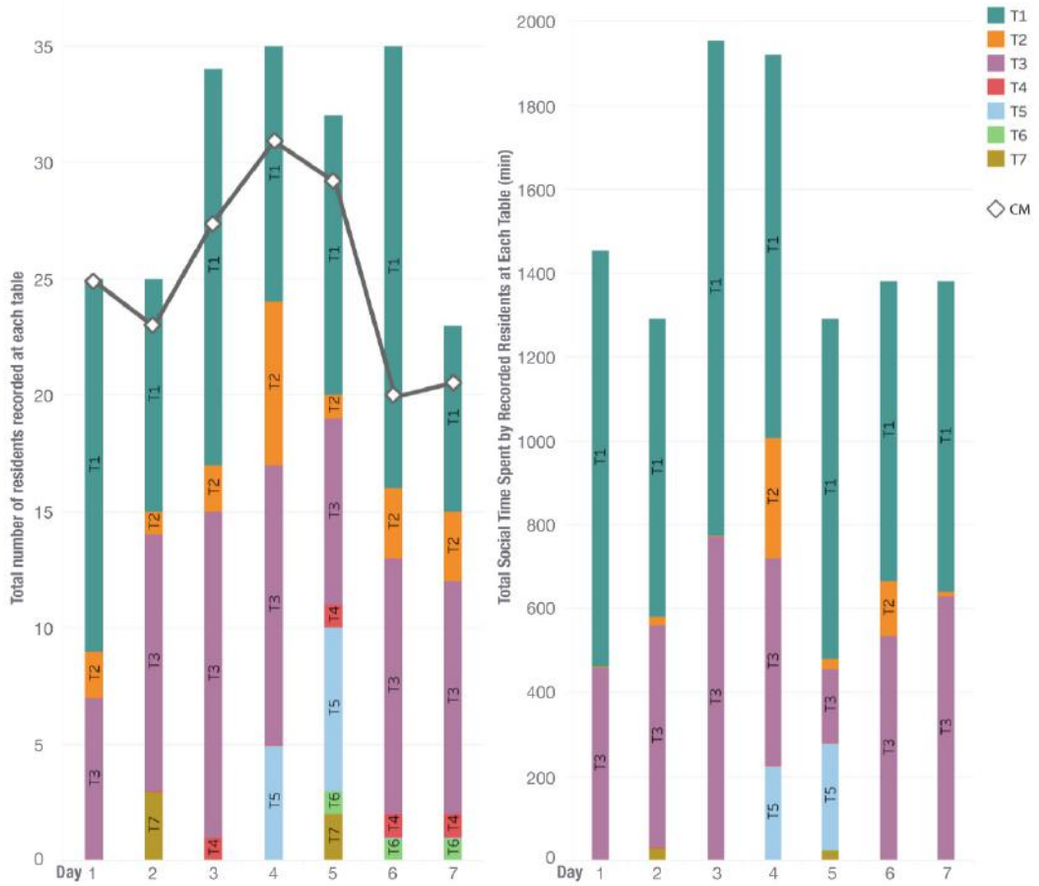


Figure 7-14 Left: The total number of the residents recorded at each table on each day of Phase 1; Right: The total social time (min) spent by the recorded residents at each table in CM on each day of Phase 1.

- *1) Tables claimed by groups (T1, T3)*

Tables in this category mainly served stable social groups for daily communications. The observational data shows that there were two social groups that occupied T1 and T3 every day for their social activities. As shown in Figure 7-14, the group members made up the great majority of the residents who came to CM, and almost all the recorded social time was contributed by them. Although T1 and T3 were originally designed for 6 people, it was frequently observed that nearly 10 residents gathered around the tables simultaneously. They would rather bring chairs than sit at other

free tables. According to the field journals, the primary members usually kept sitting at the same seats for nearly 2 hours every day, and the secondary members came to sit at random seats and left according to their personal schedules. The residents who did not belong to the social groups were rarely observed to sit at T1 or T3. Furthermore, we only observed one resident who could join both social groups. No special social activities such as playing puzzles or cards were observed at T1 and T3, and talking was the primary social behavior recorded in these groups.

- *2) Unclaimed tables (T4, T5, T6, T7)*

In contrast to T1 and T3, the second kind of tables were not claimed. The tables that fall into this category were T4 to T7. As shown in Figure 7-14, the total number of residents who sat at these tables was much fewer and unstable, and the social time recorded was negligible if compared to T1 and T3. According to the field journals, they were mainly used by the residents who do not come to CM very frequently. These residents could be the individuals who came to read, drink coffee or look for potential social partners, or the friends/family who came by appointment. These tables were also where some caregivers sat to rest or have short meetings. Although some of these residents might have preferred tables or seats, most of them were observed to look around and consider where to sit once entering CM.

- *3) Tables claimed by individuals (T2)*

Tables in this category were mainly used by the residents who came to CM very frequently but did not clearly belong to any social group. As shown in Figure 7-14, T2 was stably occupied every day, but the number of residents recorded was much fewer and the social time was much less than T1 and T3. According to the journals, a lady primarily sat at T2 every day in Phase 1. Her behavior at T2 was mainly recorded as sitting alone or with another lady who occasionally showed up watching others silently. Usually, most other residents would not choose to sit at T2. Sometimes they came to her for short communications. Mostly, the lady tended to leave T2 and join other tables when the social opportunity was suitable, but her social partners were not stable. Although T2 was the only table recorded in this category, the field

experimenter reported that they also found such tables outside the recording area.

Based on the classification, we aimed to explore the residents' reactions by deploying R2S on the three kinds of tables. As shown in Figure 7-15, we set the first condition by deploying R2S at T3 for a week to investigate the role that R2S could play in residents' regular social activities. The reason for putting T3 in the first condition was that these tables had relatively more stable potential users. We assumed that if the active residents could take the lead to use technological innovations in public areas, it might be a more effective promotion than the introduction week. In the second condition, R2S was installed at T4 to see if it would attract any residents who came to CM less frequently. After a week, we deployed R2S at T2 to explore the reactions of the claimer and other residents. Another reason of specially selecting T2, T3, and T4 was that they were close to each other and shared a similar physical setup. We believe that it could reduce the effects of some external factors such as noise, views from the seats, and distance to the bar, as we found in the case study of OutLook (Chapter 3). Additionally, since T2, T3 and T4 were observed together, we could also explore the impact of R2S on its surroundings.

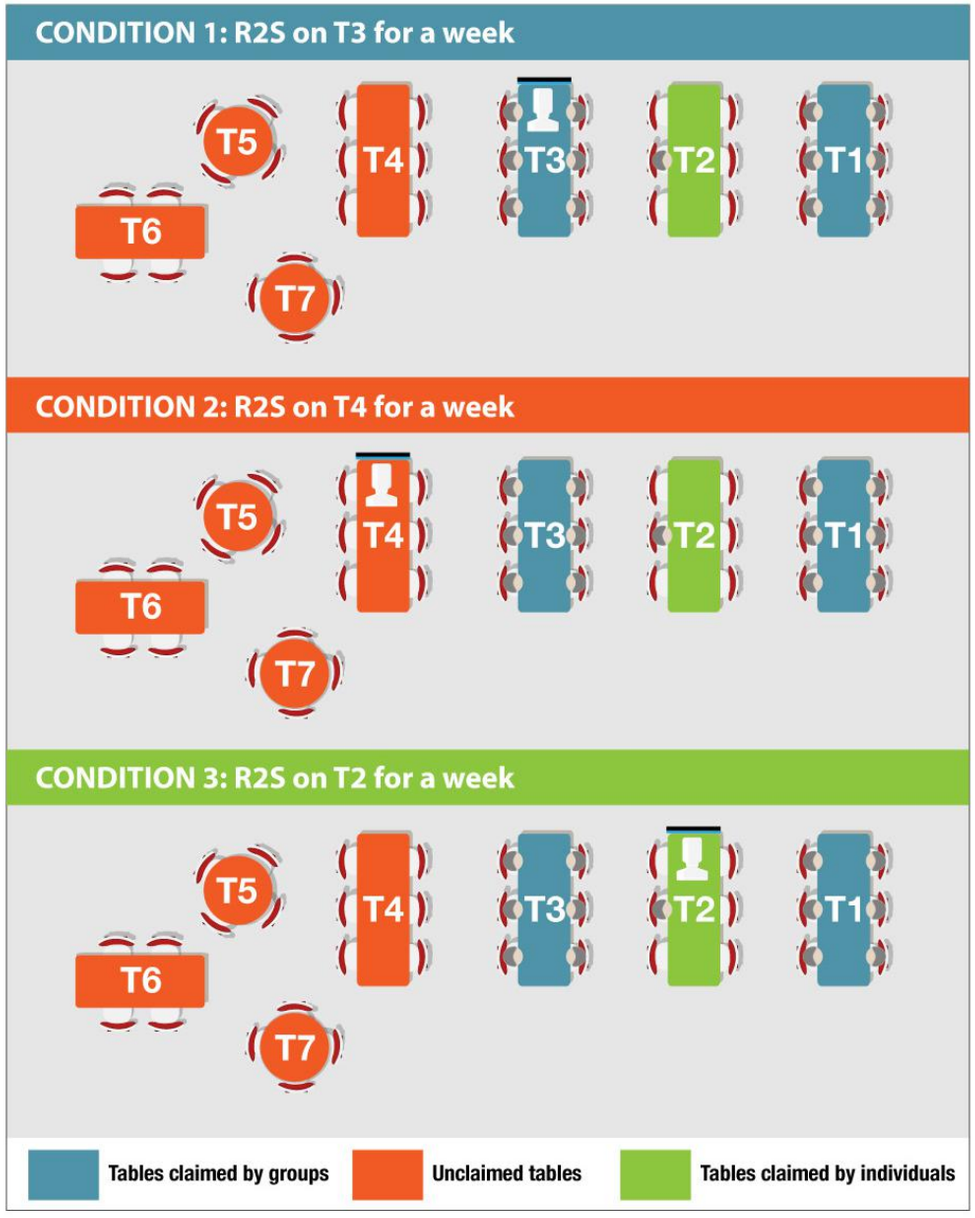


Figure 7-15 R2S was deployed on one of the three kinds of tables as three conditions (each for a week).

7.10 Results

7.10.1 Impact of R2S on Residents' Daily Behaviors (Q1)

The residents' general reactions to R2S could be directly reflected in the number of residents who came to each table (Figure 7-16) and their time spent at the tables (Figure 7-17). Although nearly half the area of CM was recorded, we mainly demonstrate the situations at T2, T3 and T4 because they were directly related to this study. No significant change was observed at other tables.

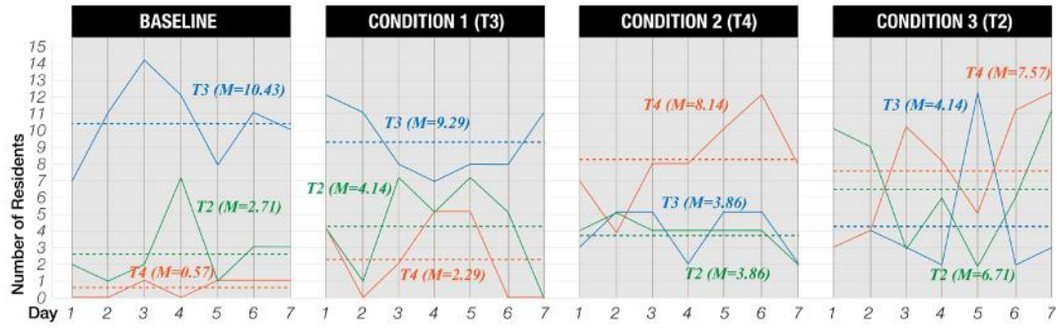


Figure 7-16 The total number of the residents recorded at each table on each day of the baseline (Phase 1) and the three conditions.

In Condition 1, T3 remained to be a popular table after the deployment of R2S. Compared with the baseline, both the average number of residents and their time spent at T3 changed very little. Given many residents' resistance to novel technological applications, it was encouraging to see that R2S did not scare away the social group at T3. It seemed that the introduction week played an important role in improving their acceptance. According to the field journals, the social group kept their daily routines and integrated R2S in their social activities. Furthermore, we found R2S could attract many residents passing by. They stopped and asked about the design. If they were interested, they tended to stand for a while or sit on their mobility aidzs to observe others using R2S. Sometimes the group members at T3 would invite and help these residents join if there were available seats. However, since T3

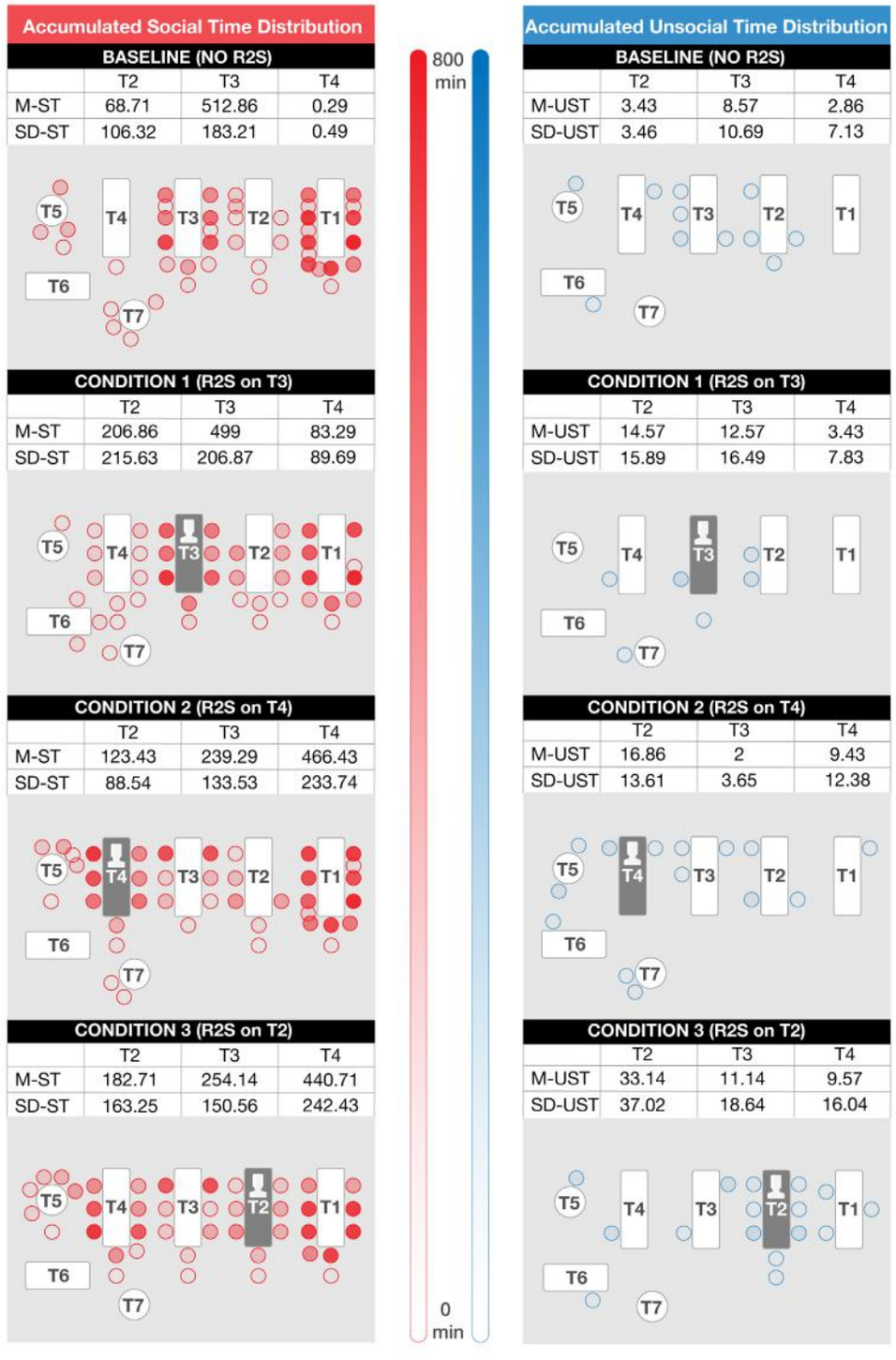


Figure 7-17 The total social time (red) and unsocial time (blue) spent by the recorded residents at each table on each day of the baseline (Phase 1) and the three conditions in Phase 3.

was already used at full capacity before the deployment, there were often no seats left for the new members. Therefore, some of them chose to sit at other tables nearby and wait for social opportunities or available seats at T3, which could explain the improvement in both the average number of residents and their time spent at T4 and T2.

In Condition 2, there was a significant rise in the number of residents who came to T4, and we recorded significantly longer social time at T4 than the previous week. Meanwhile, the residents who stayed at T3 were much fewer. According to the video records and field journals, we found the situation occurred mainly because many key group members at T3 followed R2S to T4 since the beginning of Condition 2, which was encouraging but also surprising because Condition 2 was initially set to explore if R2S would attract some residents who did not frequently come to CM. We had not anticipated that the group members would change their accustomed seats for years to use R2S. Furthermore, as shown in Figure 7-16, we observed an increasing number of new residents who stopped at T4 when passing or specially came to join since Condition 2. It might be because T4 was a more open table than T3 in some residents' minds. Although some new residents were also found at T3, the number was much fewer, and they didn't come regularly.

In Condition 3, overall, both the average number of residents and their total time spent at T2 reached a peak in the four weeks while the average situation at T3 and T4 changed little compared with Condition 2. Specifically, in the first two days of Condition 3, we saw a substantial increase in the number of residents at T2 while the number at T4 sharply dropped. According to the journals and video records, we found that many residents who came to T2 were from the group at T1. It seemed that they were attracted out of curiosity. The key group members at T4 did not follow R2S to T2 as they did in Condition 2 or sit back to T3 where they used to sit. They kept sitting at T4 but the residents who joined were fewer. As time went by, since the key group members kept sitting at T4, we found the social situation at T4 gradually restored to its previous state in Condition 2. Besides, we found that the additional group members at T2 moved back to T1, which resulted in a significant decline in the number of residents. However, it also provided opportunities to some individual residents who did not belong to any stable

social group. Usually, they just passed or stayed in CM very shortly if there were no social opportunities. But in this condition, they were occasionally observed to be attracted and use R2S alone at T2, which could explain the unsocial time spent at T2 in Condition 3 was the longest. Furthermore, we found an increasing number of new residents joined as they gradually got familiar with R2S.

7.10.2 Residents' Usage of R2S (Q2)

- *Residents' time spent on using IStamp*

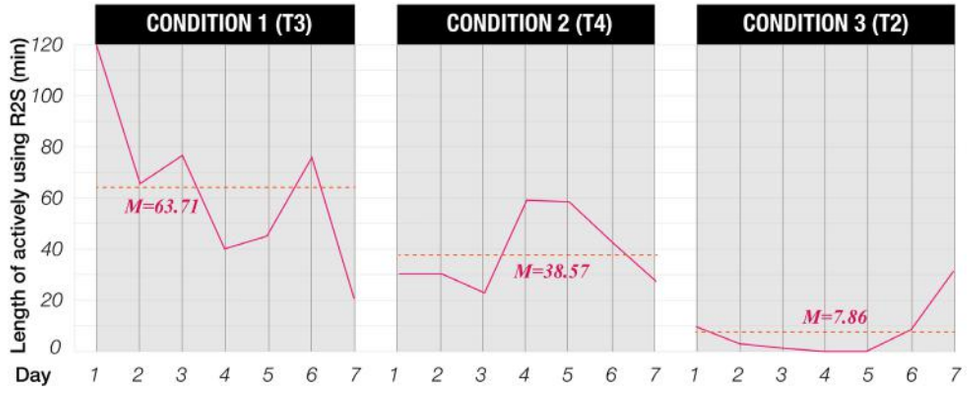


Figure 7-18 The total time spent on using IStamp in the three conditions of Phase 3.

Figure 7-18 shows the total duration of using IStamp on each day of the three conditions. In Condition 1, IStamp was frequently used by the social group at T3. The average duration of active use reached over one hour per day. On the first day of the deployment, the residents used IStamp throughout the two hours. The field journal indicated that the group members who had joined the introduction showed no difficulties in using, and IStamp was often used for demonstration and teaching others. As more residents learned, the duration of use declined in the following days, fluctuating around one hour. On the last day, it seemed that most group members had got used to R2S, and the duration dropped to about 20 minutes. In Condition 2, since

many active users were from T3, and R2S had been integrated into their daily activities in CM after one week of use, the duration of active use tended to be very stable. With more new residents joined, the average duration of use per day was more than half an hour, which was slightly higher than the later period of Condition 1. In Condition 3, although the average number of residents and total time spent at T2 was the highest, we found IStamp was rarely actively used. The field journals and videos indicated that the residents tended to use R2S in a more passive way. They preferred to flip the newspapers and watch the slideshows. It might be because most residents recorded in this condition didn't join the introduction, including the lady who used to sit at T2. It seemed that the physical and digital tutorials were not as effective as we expected. The lady touched IStamp for the first time at the end of the sixth day under the guidance of another resident who was attracted and joined her. On the last day of Condition 3, we surprisingly found that the lady could actively use R2S independently and attracted many other residents. The duration of use rose sharply to the average level in Condition 2, which would hopefully form a steady use habit in the future.

- *Residents' detailed interaction with IStamp*

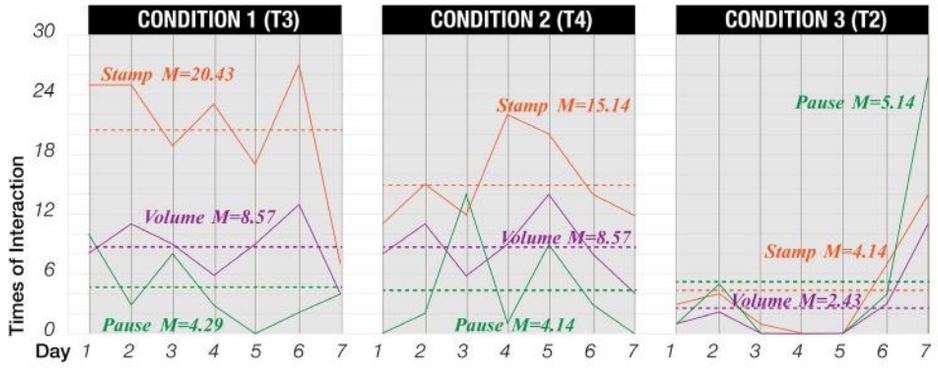


Figure 7-19 The times of each interaction with IStamp counted in the three conditions of Phase 3

Figure 7-19 shows the frequency of the detailed interactions with IStamp. Since R2S was mainly used by groups in Condition 1 and 2, we found the residents quickly developed their interaction pattern and kept it very stable

within the two weeks. As the fundamental interaction of R2S, 'stamp' was recorded most frequently. Although we only prepared 8 interactive articles per day, the average times of 'stamp' were over 20 in Condition1 and more than 15 in Condition 2. We found there were many articles that were 'stamped' repeatedly. It might be because some videos really attracted the residents and had more chances to be shared. It might also be because the residents needed to watch some videos over and over to fully obtain the information. Rotating and pressing IStamp were designed as the secondary interactions to further control the digital media. As we can see from Figure 7-19, the volume control was used much more frequently and stable than the pause operation in Condition 1 and 2. It seemed to be essential for the residents to adjust the volume according to their hearing, position and ambient noise. In Condition 3, we can see how the residents at T2 gradually accepted and used R2S, which took much longer than the residents who joined the introduction before. Pause function was used much more frequently, mainly because the lady at T2 and the new residents spent much time on getting familiar with R2S, and they might find pressing IStamp was a very novel and interesting way to control digital media.

- *Residents' preferred time period of using IStamp*

Figure 7-20 summarized the timeframes of using IStamp in the two hours of the three conditions. The darker color represents more frequent use in this period. In Condition 1, IStamp had been used throughout the two hours. Furthermore, we found it was mainly used in the first hour and the last fifteen minutes. According to the field journals, since the deployment, R2S became the topic focus at the beginning of the group activities. The group members who arrived early tended to go through all the content together or alone, which took about half an hour. Then in the next half hour, they tended to share their preferred content with others. As the group expanded, they usually engaged in intensive conversations, which was when R2S was used less frequently. In the last fifteen minutes, when many group members left in succession, the remaining residents tended to pick up IStamp again to continue and support their activities. In Condition 2, we can see that the group members developed a stable use habit. As they did in Condition 1, they preferred to use in the beginning and near the end of the period, but the length of each use was generally shorter than Condition 1, which might

be because they had been familiar with R2S and spent much less time in discovering and demonstrating. Besides, we found IStamp was also stably used in the middle of their group activities to facilitate their communications. In Condition 3, we found IStamp was primarily used in the later period of the two hours. According to the field journals, the identities of the residents at T2 were not stable and most of them didn't join the introduction. Before picking up IStamp, they tended to spend more time getting familiar with R2S.

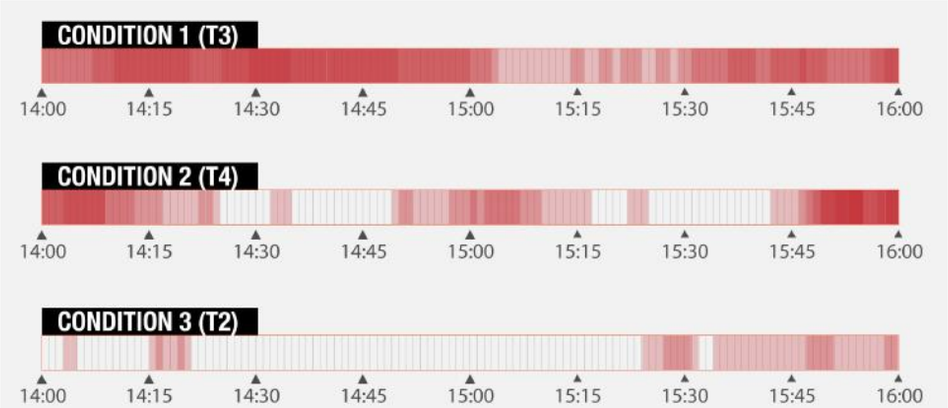


Figure 7-20 The accumulated frequency of using IStamp in each time period of the two hours in the three conditions. The darker color represents more frequent use.

- *Residents' use patterns of R2S*

The residents' typical use patterns and habits were mainly investigated through the post-trial interviews and supported by related video clips as a reference. In Phase 4, twenty-one residents who were involved in this study were recognized and invited by the field experimenter. As shown in Table 7-3, seventeen of them agreed to participate. Among the participants, six of them joined the introduction and used R2S after the deployment (Group 1). Nine participants didn't join the introduction but used R2S (Group 2). Two participants joined the introduction but didn't use it afterwards (Group 3).

Group	Joined Introduction	Used R2S	Number of Participants
1	*Yes*	*Yes*	*6*
2	*No*	*Yes*	*9*
3	*Yes*	*No*	*2*

Table 7-3 The number of the participants classified in each group for interview

Use Pattern	Number of Participants	Feature of Pattern
Active Use	*2*	*seek to use regularly*
Adaptive Use	*2*	*regularly use if they can easily get access*
Passive Use	*5*	*follow others to use*
Opportunistic use	*6*	*use only when they have the right opportunity*
Not use	*2*	*do not use*

Table 7-4 An overview of the five use patterns and key features

As shown in Table 7-4, five use patterns are identified, and their detailed features are described as follows:

Active use: Two participants used R2S very actively. Both of them had reading habits and joined the introduction, which helped them quickly accept and use R2S in their daily activities. Although they used to belong to the social group at T3, they changed their accustomed table toT4 in Condition 2. The interview indicated that R2S also changed their reading habits. One lady said: "*I used to read the articles first. Now I prefer to watch the video first if people join the table. Once they leave, I can continue reading.*" One man liked to check the slideshows to see what kind of news he could watch every

day. He said: "*if I see something that interests me, then I put the stamp there to watch the video. Whether I then read the article depends on the video. If I can get all the information, then I won't read the articles anymore.*"

Adaptive use: Two participants used R2S only when it could be easily accessed. They used it very frequently when R2S was installed at T3 where they used to sit, but they did not use it in the following conditions. One man mainly got news from television and joined the introduction. Another man preferred to read newspapers in his room and learned to use R2S from others. They came to CM very frequently to exchange the latest information with each other. Both of them agreed that R2S enriched their daily communication, but they would not seek to use it. They mainly watched the slideshows to see if there was any information that they missed in their rooms. They also tended to be very selective in sharing the content. One man said: "*The articles have to be attractive. When people are drinking coffee, I am not going to share a video about Ebola.*"

Passive use: Five participants used R2S very frequently, but mainly in a relatively passive way. Two of them had joined the introduction, and the others gradually learned from others. Most of them had stable social groups. They were attracted and motivated by the use of their social partners. However, due to technological acceptance or personal character, most of them preferred to follow others to use. One lady who rarely used new technologies before said: "*I haven't touched the stamp. I just joined the table to watch the videos. I read the newspaper in between.*" Another lady described her experience: "*I watched when others were using, and I find it relaxing to watch and then laugh or talk about the videos now and then.*"

Opportunistic use: Six participants used R2S less steadily, mainly when there were suitable opportunities. Only two ladies had joined the introduction. One of them did not belong to any social group before, but she was attracted to join others to use R2S in Condition 1. However, she complained that she did not have many opportunities to use it further. "*I do like it. But there were always many people around it. I have no chance. There was one time that they weren't there, and then I got the opportunity to hold it.*" The other lady belonged to a social group in the other half of CM, so she didn't join other groups to use R2S in Conditions 1 and 2. She was also not enthusiastic

about using it alone because she could use many other new technologies. "*It works but I can already get news in many ways, on the phone, tv, iPad. I have used it a few times, but you know, when you get older your interests disappear.*" However, when R2S was less occupied by other groups in Condition 2, we found that she invited and introduced her friends to use R2S at T2. The remaining four participants usually came to CM only once or twice a week. Two of them were invited and guided by others in Conditions 1 and 2. The other two individuals were attracted and had the opportunity to try R2S in Condition 3. They mainly learned from the tutorials on the screen by themselves. "*I know that people were watching it, but I didn't know how to do with it in the beginning.*", one man said.

Not use: Two participants did not use R2S although they had joined the introduction. One man rarely came to CM because he had voluntary work outside the nursing home. The other lady saw others using but she did not join. She preferred to sit at 'her' table, reading her newspapers alone. "*I think this is appreciated by many people here. But I'm not the kind of person that easily tries new things. When I see something, it's not my first thought to look at it or touch it.*" She also worried that people might gossip if she joined a social group that she did not belong to. "*Everything you did here goes around very quickly*.", she said.

7.10.3 Residents' Perceived User Experience (Q3)

The interviews with the participants of Group 1 and Group 2 (Table 7-3) indicated that their overall user experience was very positive. All of them thought it was very practical to digitally augment newspapers, which made it much easier and more attractive to read newspapers in CM. "*Especially for the ones that cannot read very well. They can now watch and hear it!*", one man said. Furthermore, they appreciated that R2S provided better access to the latest news. Another man said: "*I like that it gives more information, more in-depth. Something that I can see on TV but the other ones I cannot see on TV. Therefore, I like to be able to see news from other sources as well.*" One lady also compared R2S with TV, and she said: "*The stamp certainly changes something. I really like it. We see something new.*

Usually, we can see things on television, but this is different." Most of them were satisfied with its appearance. "*It's a beautiful thing that you have engineered.*" One man remarked. Another man mentioned the importance of the volume control function. "*I am a little bit deaf, and I therefore need to put the volume up, but sometimes I had to put the volume down when other people joined.*" Besides, many participants complimented the slideshows. One lady emphasized: "*I really like the pictures in particular.*" Two men also mentioned their habits of checking the real-time ambient display. "*We both liked to check the temperature and saw it rising during the day. It made sense to us because inside here you don't get a good impression of the actual temperature, and people here are losing the ability to sense it.*" "*We also see the weather forecast. Many people here want to know if there is a chance to rain and then they decide whether to go outside. I know there are applications (on the phone) but many people don't use that.*" Furthermore, the sociability of R2S was acknowledged by many participants. One man said: "*When the stamp caused people to talk to each other, I think that is very interesting.*" A man who used to read newspapers in his room changed his habit because of R2S. "*Now I prefer to read the newspaper and watch the videos here, surrounded with other people because then you hear people talking about it.*" One lady also expressed similar feelings: "*I find it exciting to use the stamp with others and I am curious how other people think of the news.*"

Some participants also described their negative experiences, which revealed their future demands. Two ladies wished more units could be installed because their usage was restricted if R2S was occupied by someone that they didn't like. It was also necessary for the residents with different interests. Many people changed their accustomed seats because they wanted to sit close to the display for a better view, which sometimes resulted in the dissatisfaction of others. "*Everyone 'has their own chair here' and then I had to move because of the screen. Changing things was very difficult here.*", one man said. Therefore, one lady suggested that the screen could be bigger. In addition, another lady hoped that more group members could influence the displayed content to enhance their mutual connection. She said: "*The news is for everyone and there are different kinds of things for everyone but mostly the people who have the stamp decide what is on the screen.*"

All the fifteen participants of Group 1 and Group 2 agreed to fill in the UEQ-S questionnaire and fourteen participants completed it. One participant dropped out because she had difficulties in understanding some items and the seven scales. The completed questionnaires were transcribed into the Short UEQ Data Analysis Tool. The mean result of the pragmatic quality, hedonic quality and overall attractiveness is shown in Figure 7-21. The items in UEQ are scaled from -3 (horribly bad) to +3 (extremely good). But in real applications, it is unlikely to observe values above +2 or below -2 due to the avoidance of extreme answer categories. According to the handbook of UEQ-S, +0.8 and -0.8 were defined as the critical values for evaluation. Overall, the result of the UEQ-S questionnaire was in line with the feedback in the interviews.

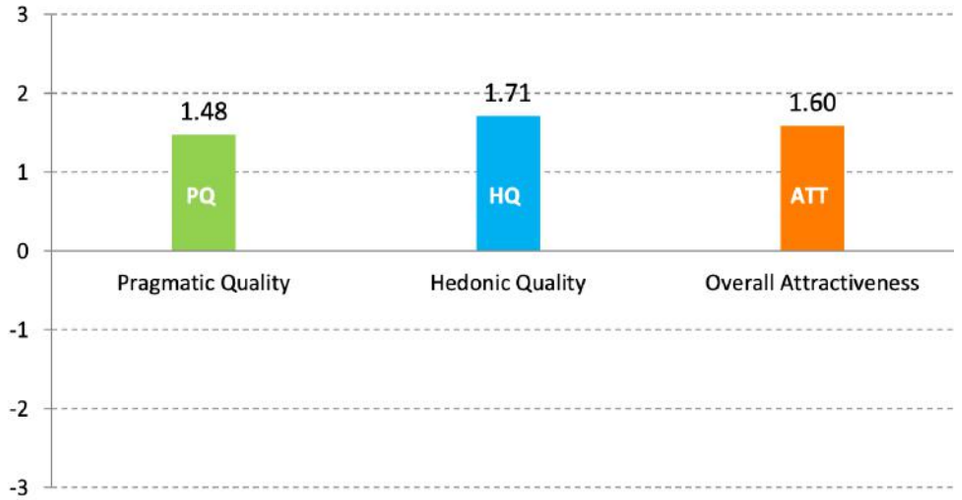


Figure 7-21 The mean result of UEQ-S in the domain of pragmatic quality, hedonic quality and overall attractiveness

As shown in Figure 7-21, all the mean values of the three attributes are well above +0.8, which suggests that the participants generally had a very positive user experience from using R2S. Besides, the hedonic quality receives a higher rating than the pragmatic quality, although the difference is small. The mean result per item in Figure 7-22 indicates that all the metrics were rated to be positive. However, there is still room to improve the attributes of pragmatic quality, especially making R2S more efficient to display what users want because some participants complained that sometimes it was time-consuming

to search IStickers, and sometimes they couldn't influence the content as they needed. Furthermore, it seems that R2S was less supportive for the residents who had little interest in reading newspapers.

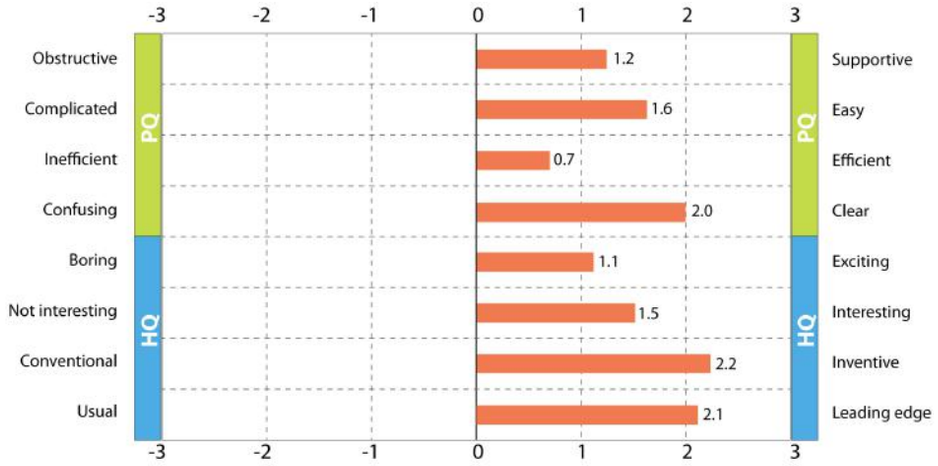


Figure 7-22 The mean value per item in UEQ-S

Figure 7-23 shows the comparison between scale means and the UEQ benchmark that was extracted from a large dataset of UEQ results from 246 interactive products. It indicates that the overall attractiveness and hedonic quality is rated to be excellent, which means the value is in the range of 10% best results. The mean result of pragmatic quality is located in the Above Average category of the benchmark, which further confirms that future refinement of R2S should focus on efficiency and practicality.

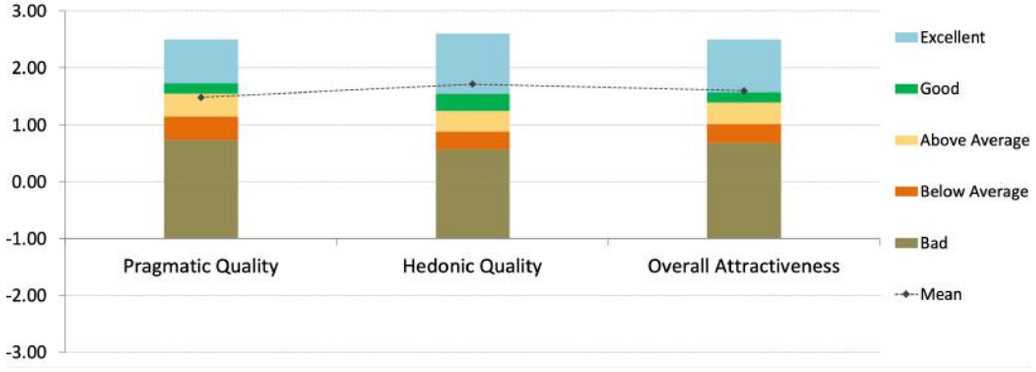


Figure 7-23 The comparison between scale means and the UEQ benchmark

7.10.4 Residents Perceived Social Feelings (Q3)

The participants' perceived social feelings were investigated through the structured questions from the ABCCT questionnaire with the fifteen participants in Group 1 and Group 2 (Table 7-3). The questions highlight both affective benefits and costs that a socio-technical system may bring to the users.

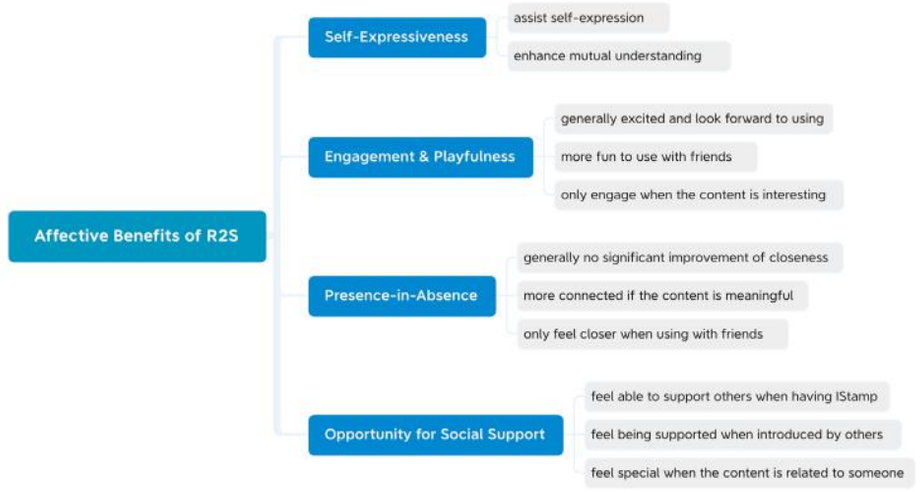


Figure 7-24 A summary of the participants' key statements about the affective social benefits of using R2S

Figure 7-24 shows a summary of the participants' opinions on the four aspects of the affective social benefits of using R2S. Each aspect is further explained as follows:

Affective Benefit 1: Self-Expressiveness

The questions originally aimed to assess whether social technology enables the users to express their feelings and perceive the feelings expressed by their partners. Since R2S was designed to trigger and facilitate nursing home residents' communications via general news sharing, we modified "Emotional Expressiveness" to more general "Self-Expressiveness" including one's preferences, interests and emotions. All the participants agreed that using R2S

could help them express themselves and understand others, especially for the secondary group members who usually played a following role in the social activities and those who came to CM less frequently. "*Yes, I get insights in other people's interests because of the videos. If I didn't watch the videos, I cannot talk about it or get these insights.*", one man said. However, for the key social group members who meet each other very often, the benefit seemed to be insignificant. "*I already know about other peoples' interests because I speak with a lot of people. Watching and talking about the news can be an extension of our conversations, but the base is already there.*", one man remarked.

Affective Benefit 2: Engagement & Playfulness

Questions in this section were asked to explore whether the social interaction via a certain technology (R2S) is fun and exciting to the participant. The participants' feedback was generally positive, but the degree of engagement varied with the individual's personal situation and user experience. Seven participants clearly answered this section. Three participants directly said they were excited and looked forward to using R2S, especially when using it with other people. Two participants said it was fun when they were using with their friends, but they felt neutral if more unfamiliar people were involved. One man agreed that it depends on the people, and also depends on the displayed content. "*You certainly have to pick the right video for the conversation, then you talk more easily. For me, I don't like sports and football in particular, so I won't listen if people watch that.*", he said. One lady claimed no significant mood swings during use. "*In normal situations, I think it's fine, nothing special.*" Besides, she mentioned that she might feel upset when people say rude things or have arguments.

Affective Benefit 3: Presence-in-Absence

Presence-in-Absence is defined as a "*subjective sense of social others whilst separated from them by time or space*", which mainly aims to investigate if the social technology can foster feelings of "closeness" (Yarosh et al., 2014). Most participants had difficulties in understanding and answering these questions, and they thought it depended on the situations. Generally, all of them did not feel significantly closer to others, especially for the key group

members who claimed that they already had very good connections with others. One man mentioned that it might be because the shared information was mainly superficial news that was difficult to enhance their emotional bond. He suggested that the shared videos could have a deeper connection with the information rather than just explaining what happened. Some participants had closer feelings when using R2S, but only with their friends. One man said: "*I get a better and better connection with him, but as soon as other people got involved, it was annoying.*"

Affective Benefit 4: Opportunity for Social Support

This section aims to ask whether social technology provides users with opportunities for social support. A typical question is, "*Does using R2S make you feel special or supported by others?*" We found almost all the participants could not give clear answers because it depended on situations. Two participants said that they felt very good when they had IStamp. "*Reading the newspapers and watching the news on TV has always been an individual activity. I feel like this (R2S) can bring each other further.*" Some participants who had not joined the introduction mentioned that they felt supported when others explained and guided them to use the system. In addition, the participants who mainly used R2S passively claimed that usually they didn't feel special, and it mainly depended on the videos and the discussed themes. "*It is special if the news touches people or relates to someone.*", one lady said.

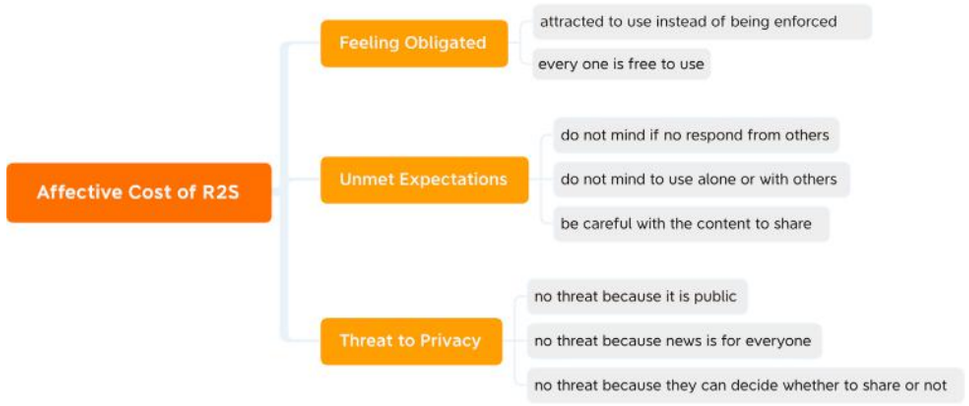


Figure 7-25 A summary of the participants' key statements about the affective social costs of using R2S

Figure 7-25 shows a summary of the participants' opinions on the three aspects of the affective social costs of using R2S. Each aspect is further explained as follows:

Affective Cost 1: Feeling Obligated

The first affective cost explores whether social technology leads to an unwanted obligation to communicate with others. None of the participants clearly felt obligated when using R2S. For the participants who mainly joined others or passively used it, they claimed that they were attracted rather than enforced. "*I watch the videos because I want to.*", one lady said. Another lady expressed similar feelings: "*I was not forced to do anything. I decided that for myself.*" For most stamp users, they mainly treated the social interaction as an added value rather than the ultimate goal of using R2S. One lady said: "*I have never felt an obligation. I just use it and if other people want to use it, they can use it.*" Only one man mentioned an unwanted experience when he had IStamp. "*I was asked to put the stamp on a sticker on a particular page. I liked to help, but it's better not to react if they asked you all the time.*"

Affective Cost 2: Unmet Expectations

Since many social technologies might increase the expectations for communication, some questions were asked about the situations where unmet expectations result in negative affect (Yarosh et al., 2014). Most participants claimed that they rarely had such feelings. One lady who mainly passively watched said: "*I don't mind watching the videos alone or with other people.*" Another lady who frequently used IStamp had similar thoughts: "*I don't mind if people don't respond to me. Everyone is free to do what they like.*" One man said that he generally didn't have high expectations when using R2S because the situation happened very often where people here didn't respond to each other, but it also depended on the topics and people. "*There are a lot of things that I want to discuss. But many people haven't had the education to understand those kinds of things. And I have to be careful with what kind of videos to show. If it is too difficult for the people, then they cannot follow.*" One man admitted that sometimes he had such feelings when some topic interested him very much. "*I don't mind sitting alone with it, but sometimes I find upset when people don't want to talk about the topics. But yes, everyone has their own opinions.*"

Affective Cost 3: Threat to Privacy

This scale includes concerns over the disclosure of one's privacy via using social technology. None of the participants had felt their privacy had been invaded. One reason was that R2S was installed in the public space. One man said: "*I don't mind. It is in an open space, and people can use it with me.*" Another reason was that the displayed information was mainly general news that was appropriate to be watched and discussed by most residents. One lady said: "*No. The news is for everyone, so I don't think privacy is relevant here.*" Furthermore, many participants appreciated the sense of control provided by R2S. "*We share certain things with each other when other people are not around. If there are others around, I don't share everything.*", one man said. Another man also agreed that they could control what and when to disclose: "*If I don't want people to see what I stamp then I just don't do it. If you put the sticker on a playboy, I wouldn't share it here in this public space.*"

7.11 Discussion

In this section, we firstly discuss the result by conceptualizing the user types and an interaction framework of tabletop IPDs in nursing homes. Then, based on the results, we summarize the social roles of tabletop IPDs in nursing home residents' daily life.

- *Conceptualized user types and interaction framework*

As mentioned in Chapter 2, various models have been proposed to summarize the user types, interaction phases and zones of IPDs. However, all of these frameworks were developed based on their default scenarios where younger people interact with typical situated large displays in conventional open public space such as city squares, which lacks the consideration of special user groups and social settings. In this field study, we observed how R2S influenced the nursing home residents not only at its table but also in its surroundings. Building upon previous research and our findings, we conceptualized the user types and interaction framework of tabletop IPDs in care settings, which could be a supplement to the universal models presented in earlier studies.

Generally, four types of users in public meeting spaces of nursing homes were observed in this study: ***actors***, ***spectators***, ***bystanders*** and ***outsiders*** (Figure 7-26), which is conceptualized based on the three classes of users proposed by Finke et al (2008). ***Outsiders*** refer to the residents who temporarily paid no attention to the public tabletop display. Although Finke claimed that even the non-users are one type of user, outsiders were often excluded by previous researchers, which is reasonable because most people in conventional public spaces would directly pass the area if they didn't notice the display. Therefore, these people were usually not considered as common user types. Different from most conventional public spaces, the shared spaces in nursing homes are usually where a similar population enter and leave every day. In this field study, we found that many residents didn't notice the existence of R2S immediately, especially those who didn't join the introduction. One reason is that tabletop displays are usually designed not as prominent as large situated displays to avoid disturbing the surrounding

areas. Another reason might be that many residents had gotten used to the environment and would not pay special attention to it at once. However, even though many residents paid no attention to the display in the beginning, we found many outsiders kept staying around the display or passed by later, which means they are more likely to notice and interact with the display than the outsiders in conventional public settings. Furthermore, we found they played an important role in the transition between different user types. ***Bystanders*** are the residents who were attracted but not directly involved in using the display. They usually can partly watch the display content and observe other active users using it from a third-person perspective. Based on the activity patterns categorized by Brignull and Rogers (2003), we further divided bystanders into *focal bystanders* and *peripheral bystanders*. *Focal bystanders* are the residents whose activities indicate a focal awareness of the display. These residents mainly stopped nearby the table with the display, engaging in social activities such as observing others using, pointing to or talking about the display. *Peripheral bystanders* are the residents whose activities implied a peripheral awareness, e.g., we found an increasing number of residents sitting at T4 in Condition 1. They mainly engaged in their own personal or social activities with peripheral attention to the display and related activities at T3. ***Spectators*** refer to the residents who are engaged in watching the displayed content without directly controlling it. ***Actors*** represent the residents who play a leading role in using tabletop IPDs by selecting and manipulating the content to be displayed.

Based on the results, a framework is conceptualized to describe how nursing home residents move around and interact with tabletop IPDs in their meeting space. It illustrates the typical behaviors and the transition threshold between different types of users. As shown in Figure 7-26, most residents enter their public meeting space as outsiders, looking around to check the availability of the seats or the ongoing social activities in the area. For the outsiders who intend to stay, if the display is deployed on the table where they used to sit or they have used it before, they can directly go to interact with the display as actors or spectators. If the display is nearby their accustomed or chosen table, they might be aware of the display as peripheral bystanders by glancing. For the outsiders who pass by the area, as they move closer to the display, they might stop and turn to focal bystanders if they are attracted by the display or related activities. If they are interested, they can keep staying nearby as focal or peripheral bystanders or participate in direct interaction

with the display. According to our findings, the chance of participation is mainly determined by several factors including the attractiveness of the content and design, the availability or accessibility of the seats, the personal character of the bystanders or the direct users, and their mutual relationships. Once the bystanders join the table, their roles mainly shift between actors and spectators by controlling and watching the displayed content. If the bystanders no longer have interest in the display or cannot join, they are likely to move away as outsiders. The actors and spectators can also transit to outsiders by dropping out if they have other things to do.

Apart from the typical behaviors and transition threshold, our framework also marks four zones where each type of user is more likely to be observed. Similar to other interaction models of interactive public displays, this framework depicts an idealized conceptualization. The size and shape of each zone can be affected by different attributes of the display, interface and table layout in other cases. Furthermore, different from many other contexts, residents' stay in this area can be influenced by other factors rather than only the display. Therefore, the user types are determined not only by residents' distance and orientation to the display but also by their attention and interaction. For example, outsiders can also be observed at the deployed table if the users are distracted or engaged in other activities. However, we believe this framework can support the design and development of tabletop IPDs in public care environments because it covers most typical scenarios.

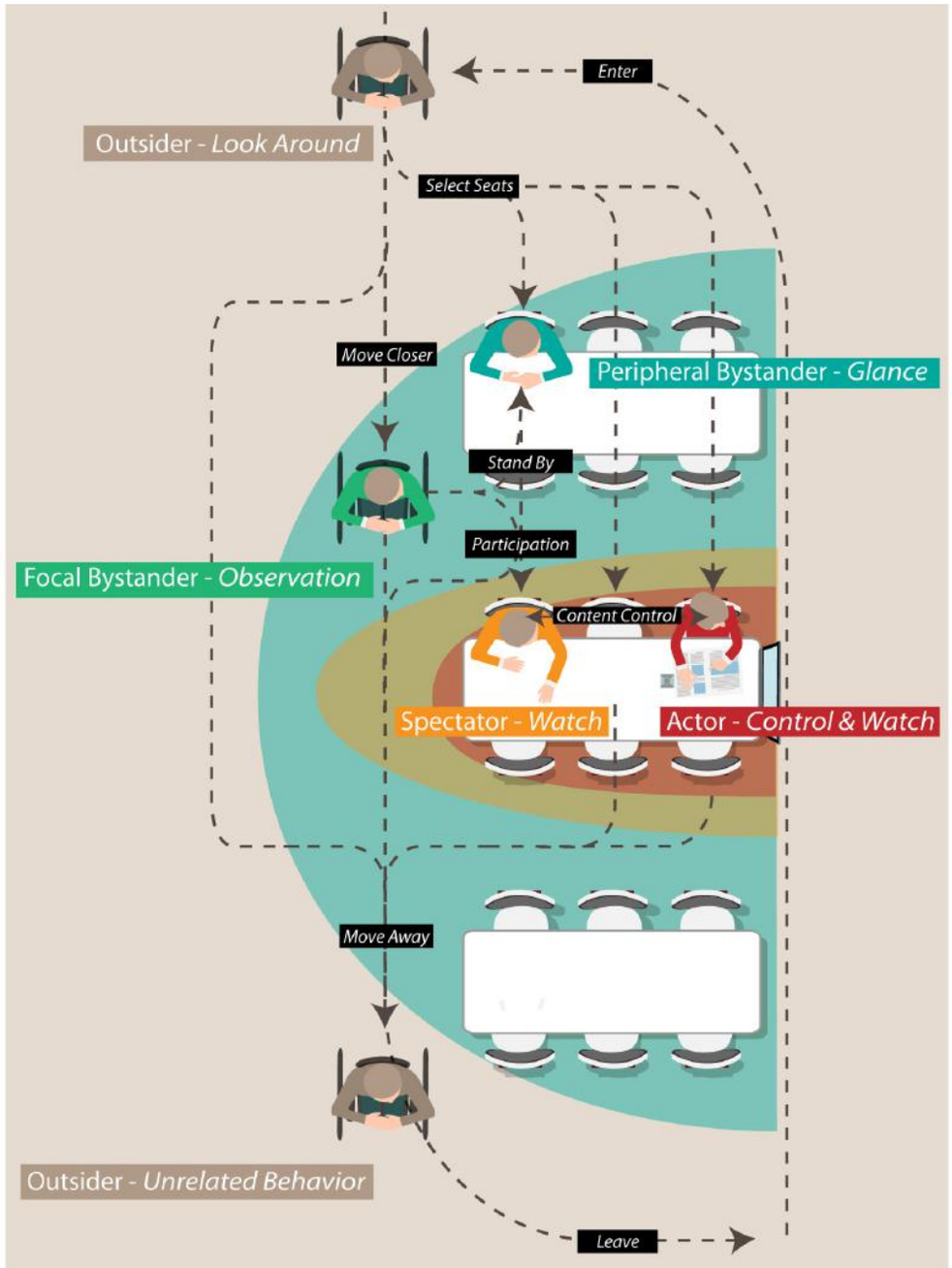


Figure 7-26 The conceptualized user types and interaction framework of tabletop IPDs in nursing homes

- *Social roles of tabletop IPDs in nursing home residents' daily life*

From this study, we identified four kinds of roles that IPTD could play in nursing home residents' social lives: ***companion***, ***inviter***, ***initiator*** or ***mediator***, and ***reactivator*** (Table 7-5). The roles were usually determined by the residents' personal habits, social relationships and situations. Based on the result, we discuss how tabletop IPDs could support and facilitate the social activities of different residents in various situations.

Situation	Social Role	Social Function
sit alone	*companion*	*provide companionship and attract others*
pass the public space	*inviter*	*invite residents to join others*
in a small group	*initiator / mediator*	*start and mediate communications*
in a medium sized or larger group	*reactivator*	*peripherally provide information and reactivate communications*

Table 7-5 An overview of the social roles of tabletop IPDs in different situations

For the individual residents who stay alone in the public space, tabletop IPDs can play the role of ***companion***. In this study, we found many residents who belonged to stable social groups often showed up early and waited for their social partners alone. We also found the residents who did not have stable social groups were often observed sitting alone for opportunistic social contact. However, there were very few facilities specially designed to support individual activities. They could only read, which was difficult for many residents in public areas, or watch and do nothing, which might make them look lonely and pathetic. The lack of supported activities could have a negative impact on residents' motivation to go to and keep staying in the public space, which might further reduce their social opportunities. In this study, we found R2S provided an effortless and pleasing way to fill the gap. The residents could either actively use the stamp or passively watch the slideshows or ambient information. Furthermore, residents could obtain and preview information for later sharing and discussion with their social partners.

For the residents who pass the public space, tabletop IPDs can be an ***inviter*** to motivate them to join groups or other individuals. Our observation in Phase 1 indicated that many tables were claimed by groups or individuals, which could provide conveniences to the claimers, but might exclude other residents from joining. The interviews also indicated that most residents preferred to stay with the people who they were familiar with, and their personal relationships were very difficult to be changed only by using social technologies. However, R2S still showed its ability to influence residents' current group compositions and create new social opportunities. During the deployment, we found R2S could often trigger the social interactions between the users and the residents passing by. Some even joined the table to use together, which means R2S could reduce the sense of territory and make the social platform more open to general residents.

For the residents in small groups (3-5 people) or pairs, tabletop IPDs can play as an ***initiator*** or a ***mediator*** for communication. In this case, we found R2S was used most actively and frequently in the first an half hour when some group members started to join. The residents who had previewed the content tended to share their preferred content. As they reflected, watching and talking about daily news was a good way to start the group conversation, and their views on the content could be exchanged in depth and detail via video-mediated communications. In this situation, R2S was usually used "in the spotlight", under the residents' continuous focal attention.

For the residents in medium-sized (6-10 people) or even larger groups, tabletop IPDs tend to stay in backstage to provide peripheral information and mainly work as a ***reactivator*** to sustain the social interaction when needed. In the field trial, we found R2S was used much less actively and frequently when the group expanded to middle size. It was mainly because most group members could already engage in intense communications and the topics could extend to their own lives. During this, R2S was not directly involved in residents' social interactions, but it could still provide ambient information for those who were shortly distracted from the group communications. We also noticed that the stamp was regularly picked up again in the middle of the two hours when the conversations cooled down. In this situation, the use of R2S was mainly to ensure a smooth transition between topics and continue the vitality of the group.

7.12 Implications of Design and Deployment

Based on our findings, results, and discussions, four key implications are identified to inform future design and deployment of IPD systems in nursing homes for residents' social interaction.

- ***Consider the invisible social tags***

The analysis of the data in Phase 1 identified three kinds of tables with different social attributes, which was rarely mentioned in previous studies. These social attributes were formed implicitly through the residents' long-term use, which could provide social conveniences for the claimers but might also create higher barriers for others to use. Therefore, before designing public socio-technical systems in nursing homes, researchers and designers need to understand that some areas or objects in public care environments are likely to be given such invisible social tags, which could surely influence the usage and social effects of the introduced systems. *Multiple units of the display should be deployed on different tables to provide equal access for the residents with different social habits*. Furthermore, *the interactive features and display properties of each unit can be adjusted according to the social attributes of the deployed tables*. For example, the units on the claimed tables should better support group activities by using larger screens and adding content controllers for more users. The units on the unclaimed tables should be able to attract individual residents and provide necessary guides.

- ***Design for various use patterns***

From this study, we found that not all the residents had the ability or willingness to engage with R2S in their daily lives deeply. However, most of them could find their preferred way to use it, which contributed to their generally satisfying user experience during the deployment. From the interviews, we summarized five use patterns including active use, adaptive use, passive use, opportunistic use and not use. We believe tabletop IPDs in care environments should be designed and deployed for all the use patterns.

It is important to *keep the residents' enthusiasm to explore, to maintain their active use*. Providing rich information resources and updating content to display is a promising solution. In this case, we selected about 8 augmented articles every day, which could only support active use for about one hour. Therefore, it is promising to develop new technologies to keep searching and delivering new content to meet the needs of active residents. In addition, diverse hidden functions can also be integrated to enrich their interaction with the display.

To facilitate adaptive use, the system needs to follow the residents' habits and interests because they are more selective to use. Apart from deploying on residents' accustomed tables, the types of content can be customized in advance to cater to users' interests. Automatic recommendation mechanisms can be applied through ambient displays to motivate them to use and socialize. In addition, the key interaction to select and control content should be very quick and simple.

For the system to support passive use, the users' audio-visual experience should be ensured. The display properties (such as size, resolution, orientation, position) need to be adjusted and tested according to specific environments and users. The images and videos would be better presented with big subtitles. The sound channel is also very important because the result shows that the volume control function was used very frequently. The sound must be clearly heard without disturbing other tables. In this case, IStamp can be used as a personal hearing aid or an audio amplifier for small groups, which was praised by many participants. However, some participants complained that they could not hear very clearly when the group expanded. Therefore, additional backup hearing devices seem to be necessary for bigger groups.

To promote opportunistic use, apart from deploying more units of displays to create more chances of use, the system should also be able to attract and guide the residents who do not frequently go to public spaces. Ambient display and interaction can be adopted to draw more attention from passersby. The main interface and interaction should be simple and clear. In addition, although not as effective as human instructions, we found digital tutorials are very important for new users to get familiar with the system quickly.

For those who do not want to use the system, the influence area of each display should be limited nearby the tables to reduce intrusiveness and minimize enforced interaction. Therefore, the screen should not be too large. Flashy graphics, sudden or continuous noises should be avoided. If the displays are deployed on large scales, necessary functions need to be designed for the residents who want to disengage with the system. For example, they can freely turn off the display or hide the screen under the table with user interfaces.

- ***Support fluid transitions between user types***

We identified four user types when residents move around the public tabletop displays. *Residents should be able to play their preferred roles and freely transit between them*. The interaction framework indicates that the transitions between different user types can be influenced by four factors including the distance to the display, the location of seats, the opportunity of participation and the accessibility to content control. In this study, R2S could generally support the transitions between different user types. Most residents could shift between outsiders and bystanders by adjusting their distance to the deployed table. With more units deployed in the future, the residents would be less restricted by the unwritten 'seating rules' in transiting from outsiders to actors or spectators. The difficulties to transit from bystanders to spectators were complained by some participants in this study, which was mainly restricted by the capacity of the table and personal relationships. To solve this, a network could be established for content sharing across the displays on different tables, which could expand the social group by involving more bystanders and supporting their transition to spectators. Another barrier complained about by some participants was the transition from spectators to actors. Their accessibility to content control was restricted by their social roles in groups. The group leaders apparently had more chances to get ownership of the content controller. To improve this, the effects of their previous social roles on using public displays should be minimized by blurring the boundary between information sharers and receivers. For example, the system could be designed with multiple devices controlled by different spectators. All of them can dynamically transit to actors by sending their shared content to the playlist of the public display.

- ***Provide extensive introduction services***

Ensuring adoptability is crucial for the success of socio-technical systems in care settings. Isaacson et al. (2019) claimed that the high adoption rates of introduced systems among older adults could be attributed to three factors: platform, system design, installation and support. Platform and system design have been explored in numerous earlier studies in the field of interactive public displays, but related support services are often overlooked. The result of our field study showed that the residents understood and learned how to use R2S mainly from three sources: introduction activities, peers' guidance and embedded tutorials. Hosting introduction activities is a typical form of support service and proved to be a very effective way to inform the residents of new technologies. The activities can play an important role in cultivating the first group of users who might be able to promote the system by teaching others in their daily use. To start the activities, *the system can be pre-deployed in the public space with the presence of professionals*. The residents who are attracted or invited can quickly get familiar with the system from the demonstrations. To ensure the effect of propagation, we suggest the *introduction activities should be organized multiple times in a weekly-based period to fit many residents' personal schedules*. Our study indicated that such activities could cover most residents who usually go to public areas, but the effects were very limited on those who always stay in their rooms. In addition, posters and invitations didn't seem to be an ideal solution to attract them due to their inactive lifestyles. According to the caregivers, they mainly come to the shared areas in *big scheduled programs, which seems to be a good opportunity to introduce the systems*. Although not as effective as human services, the embedded tutorials also proved to be useful to guide some new users without external assistance. In this case, we found that the new users mainly followed the digital tutorials while the physical ones were often ignored.

问渠那得清如许？为有源头活水来。

Why the pool can be so clear? AS fresh water comes from the source.

–《观书有感》<The Book> [AD 1161]

Chapter 8. Conclusions

8.1 Introduction

In this chapter, we summarize our findings from previous chapters by addressing the four research questions related to key design factors, user acceptance and engagement, social effects, and user involvement. Based on our reflections and results on each aspect, we draw conclusions and summarize our contributions. Lastly, we point out the limitations of this thesis, and then we briefly discuss our future work and the potential research directions in this domain.

8.2 Addressing Research Questions

In Chapter 2, we mentioned Goffman's theory to view human behavior and social interaction in public spaces through the metaphor of theatrical performance, which laid a foundation of many later designs and research on public systems. Through our studies presented in this thesis, we found that this dramaturgical perspective also applies to public care settings, which can deepen our understanding of residents' behaviors in public care environments. The public areas in nursing homes can be viewed as stages. The residents are like actors who play certain roles to manage their impression on others. They want to make a positive impression on others including their friends, acquaintances, caregivers, and visitors. From the field trials in Chapter 3 and Chapter 7, we found most of the residents who have the habit of going to public spaces showed up on a regular schedule. They were well prepared physically and mentally to maintain their impressions and satisfy their social needs by joining social groups, waiting for potential social partners, or engaging in personal activities in public spaces. However, for the

residents who don't have stable social groups, lack essential communication abilities to create social opportunities, or have no activities to engage in, they would easily give the impression of being lonely and pathetic. As indicated by our participants (especially in Chapter 4), although many residents recognize the importance of social interaction to their overall wellbeing, they tend to stay in their rooms alone if it costs them a lot to maintain a good impression in public spaces. The private area mainly serves as a backstage for the residents to relax and "be themselves". Generally, the more difficulties the residents feel to maintain their impressions on others in public spaces, the more time they would spend in their room for preparing and charging, which could further explain the common problem mentioned in Chapter 1 because what most residents are confronting are their shrinking social networks, declining social capacities, and very limited choices of activities in public care environments.

In this thesis, we conducted a series of studies to explore the potential of IPD systems to alleviate this situation. The general research question is formulated as "*How to design interactive public displays to enhance social interaction among nursing home residents?*" As described at the beginning of this thesis, we aimed to answer this general research question via four sub-questions in the aspects of design factors, user acceptance and engagement, social influence, and user involvement in the design process.

Through our field observations and residents' feedback, we found that IPD systems could also fit in the dramaturgical model. As introduced in Chapter 2, this model has been mentioned in many HCI studies on public systems, but they mainly use it to analyze users' performative interactions (Dalsgaard & Hansen, 2008; Brignull & Rogers, 2003; Jacucci et al., 2010; Wouters et al., 2016). From the open field trials of OutLook and R2S, we found that IPD systems could also be viewed as characters on the stage rather than just a theatrical property used by the actors. On this stage, IPD systems play characters who endeavor to make a good impression on the residents through performance via displaying to attract them to interact and engage in their social activities. This perspective can also guide us to answer the research questions. In this section, we explicate how the presented studies have addressed the four sub-questions, and what contributions can be generated.

8.2.1 In Response to RQ1 - Which factors should be considered when designing and deploying IPDs to promote social interaction among nursing home residents?

As indicated in Chapter 1 (Figure 1-1), the insights on the design factors of IPD systems were derived from all the studies presented in this thesis. The collected insights from each study were validated in the following rounds of studies where the new factors also emerged. All the key factors identified from these studies are summarized as follows:

- *Content*

Our studies indicated that the content is one of the first and most important factors that need to be considered because it's highly related to the acceptance, attractiveness and social effects of IPDs. Different types of content would lead to different mental models, concepts and functions of IPD systems, which can determine residents' perception of the system and their interests in using them. However, as indicated in Chapter 2, previous HCI studies on IPDs seemed to pay more attention to interaction and display technologies. The knowledge about the selection and design of the displayed content in a specific context was rarely investigated and often overlooked by many form-oriented explorations. The subfactors identified in our studies included *genres*, *media forms*, and *update frequency*.

The *genres* of content can determine whether residents would keep watching and whether the display can trigger conversations. The genres should be meaningful to general residents. Eye-catching but meaningless content might be effective to attract users for a short period in conventional public spaces such as city plazas, but they cannot support residents' meaningful activities throughout the day. Among the mental modals mentioned in Chapter 2, we explored windows (OutLook) and posters (R2S) because we believe they are more suitable to display meaningful information for residents than mirror and overlay, which was further confirmed by our participants. In Chapter 4, we present a study to investigate the meaningful genres that conformed to residents' personal and social interests. We believe the adopted method can also be applied in different cultural contexts and generate the design strategies to guide the following design.

The *media forms* can determine whether residents can obtain the information and use them as social topics. We initially investigated residents' media habits in Chapter 4, which were further confirmed by our participants in the design process of R2S (Chapter 5). The suitable media forms were initially investigated in Chapter 5 and further tested in the field trials (Chapter 6 & 7). Although print media has long been friendly to older adults, we found many residents gradually lost their abilities and interests in reading due to physical degradations. The residents' social interaction caused by the use of print media is often limited to physical exchanges. Television and radio are mainly used in private rooms rather than public areas, which decreases their social effects. Digital images with texts were found to be effective in providing an overview of the displayed information and trigger social interaction. Short digital videos with subtitles can not only provide detailed information but also mediate and facilitate residents' communication. Additionally, given the various sensory loss of many residents, utilizing multisensory media forms is more recommended.

The *update frequency* of the displayed content is crucial for user stickiness that indicates whether users keep coming back and the resulting social interactions. Different from many conventional public spaces such as airports and libraries, the people moving within public care environments every day are almost fixed in a relatively long period. From the field study of OutLook and R2S, we clearly saw a decline in residents' active use if they repeatedly watched the same content. Our studies indicated that the content should keep changing throughout the day and be different every day. Furthermore, the difference between each update should be easily recognized by residents.

- *Environment*

Numerous studies in the HCI community have mainly focused on the relationship between public systems and users. But as we mention in Chapter 2, the relationship between IPDs and context is crucial as well. Especially in nursing homes, our studies indicated that the environment should be considered in the early stage of the design, which would highly influence the usage and social impact of IPD systems. The key subfactors are the physical and social environment.

Physical environment mainly refers to the location and environmental setting of IPDs. Generally, the location of IPDs in nursing homes should follow most residents' related habits and daily routines. Based on the concept of "spatial nodes" and "links" mentioned in Chapter 2 (Hillier & Hanson, 1984), we believe IPDs in nursing homes should be installed in the most popular "nodes" and "links". By comparing the case of OutLook and R2S, deploying IPDs in popular "nodes" is more recommended because residents tend to stay longer in "nodes" in a sitting position. Besides, we found IPDs in "links" are easy to be ignored by residents due to the declination of their sensibilities.

Social environment mainly means the surroundings that are influenced in some way by humans. In previous work, designers tended to highlight the presence of IPDs by putting them "under the spotlight" of an open place. However, to maintain a good impression on their peers, we found many residents appeared to be very cautious to try technologies in public. Due to such "social embarrassment" (Perry et al., 2010; Brignull & Rogers, 2003), IPDs should be put in the peripheral spots and blend in their surroundings to reduce residents' psychological burdens. Apart from this, the design of IPDs in nursing homes should fully consider the underlying social attributes of the environments. The open field trial of R2S uncovered that, even though some environments in nursing homes have identical physical settings, they might be claimed for different social purposes formed through residents' long-term habits. These unwritten rules need to be understood and used in the design process. The general design principle is that IPDs should provide equal access for different social groups and purposes.

- *Display properties*

Display properties can influence residents' acceptance, user experience and social impacts of IPDs. Although there have been plenty of explorations on display forms and technologies mentioned in Chapter 2, we still adopted conventional flat and rectangular screen as the main way to display because we believe it is still the most acceptable form for nursing home residents in our research context, which was further confirmed by our participants' feedback especially in Chapter 5. Besides the basic quality of high resolution and definition, the key display properties were found to be ***size***, ***orientation***, ***number***, ***distribution*** and ***adaptability***. The criterion for the size and

orientation is whether the display can deliver the information to its users, which needs to be tested in fields. Different from many conventional social interventions that invite all the residents to join one activity, our studies indicated that multiple displays are needed to satisfy residents' various needs and interests. We found they preferred to communicate in groups. The differences between residents should be acknowledged and respected, and any enforced sociability should be avoided. Multiple displays can be distributed in public spaces for various groups and individuals. The layout of the distribution should also follow residents' social habits. Additionally, IPDs need to be able to adapt to different scenarios. For example, the display can be folded or hidden to avoid disturbing residents who don't want to use, or the display can be mobile or portable to facilitate different social activities.

- *Interface*

Sufficient consideration of the interface can largely contribute to the acceptance, attractiveness, and usability of IPDs in nursing homes. Interestingly, we found that most of our participants had different criteria on the two subfactors: ***physical*** and ***digital interface***.

In our research context, the participants still preferred ***physical interfaces*** as the main way to interact with IPDs because they were more familiar and had more confidence to use tangible things. Therefore, our participants put very high and detailed requirements on the physical aspects of IPDs. The collected requirements are related to shape, size, material, weight, color, etc. The overall appearance of IPDs should fit the style of existing environments because most residents are reluctant to their surrounding changes. For higher acceptance, futuristic and technical sense should be minimized, and using metaphors of residents' familiar things was claimed to be more attractive. Besides, designers should consider not only ergonomic factors to lower their physical barriers, but also aesthetic, psychological and emotional factors to increase their confidence and interest to use. What's more, unlike the overall appearance, the interactive components should stand out from other daily items, and the affordance should be able to prompt residents to interact by instinct or their past experience.

The key requirement of our participants on the ***digital interface*** is as simple

and clear as possible. Apart from this, very few of them could propose specific suggestions. It might be because they lacked the experience to use digital products. But more importantly, from their points of view, IPDs should mainly present meaningful information to residents rather than various unnecessary digital interfaces that might be confusing or even intimidating. Additionally, the design of the digital interface can also refer to residents' familiar products in the physical world to reduce the psychological and technical barriers.

- *Interaction*

The interactions between IPDs and nursing home residents are often informed by the interfaces. As we mention in Chapter 2, interaction with a public system can be deconstructed into "***manipulation***" and "***effect (feedback)***".

In terms of ***manipulation***, the field trial of OutLook indicated that the fundamental principle is easy and low-effort, which was repeatedly confirmed in the design process and evaluation of R2S. The term of low-effort doesn't only mean easy to perform but also mean easy to learn and understand. Our participants also addressed the importance of the sense of control because they wanted to select the time and content to display. Based on this, some values can be added to create a better user experience and better social effects. For example, we found the manipulation of "stamping" created a playful experience because it used to be residents' familiar manipulation but triggered digital feedback, which also attracted others to try.

Regarding ***effect***, timing and form are important features. The lessons learned from the field trial of OutLook showed that the feedback of IPDs should be immediately responsive and be able to sustain users' interaction, which also guided the design of R2S. However, our supervised field trial of R2S indicated that the effect of IPDs should not only sustain the interaction of performers but also be able to support the continuous use of spectators. The "engagement gap" of different user types should be avoided, which was further confirmed in the open field trial of R2S. Additionally, although we designed some inviting effects of OutLook and R2S to attract residents, very few of our participants could notice them, which might be because of their

regular daily routines and declining sensibilities. Since their daily routines were found to be difficult to change, we recommend more efforts should be put into detecting users' social status rather than their presence or movement. The open field trial of R2S showed that R2S was often used at different time points for different social purposes. We believe the social function of R2S can be further improved if R2S can be aware of these contexts and provide corresponding effects.

- *Service*

With the deepening of our research, we are increasingly aware that designing IPDs for nursing homes includes not only the design of the systems but also the design of related services. Although service design is not the focus of our research in the first place, we find that necessary considerations of the support services can largely affect the residents' acceptance, adoption and social impact of IPDs in care environments. The important services were identified to be ***content services*** and ***introduction services***.

Content services mainly refer to the services to select, provide, update, and recommend proper content for nursing home residents' social interaction. According to our research, such services were mainly provided by care workers in conventional social interventions, which often took them great effort and a long time to prepare for an organized activity. Since our research mainly focused on the side of residents, the researchers played the role of care workers to select the content. Based on our studies and the current situation of the care industry, we believe that care workers and volunteers are still the optimal groups to provide content services, but the technologies adopted in IPDs should be able to simplify this process and reduce their workload.

Introduction services mean the work to introduce the system to residents and instruct them to use it. Since numerous residents spend most of their time in private rooms and lack awareness of the things occurred in public areas, we believe IPDs systems should be formally introduced to general residents. The field study of OutLook indicated that the introduction should be organized multiple times in a period due to different personal schedules. Both the field study of OutLook and R2S showed that the effectiveness of

posters and invitations was very limited. Hence, we assume that promoting IPDs systems in their organized activities might be a promising way. Besides, given many residents' acceptance and capacity to use new technologies, we believe necessary instruction services should be provided in the deployment of IPDs. The instructions can be provided in printed versions, in digital forms, or by care workers or residents. Our studies indicated that human instructions were the most effective way. For individual users, they tended to get instructions from the display rather than printed products. Additionally, it seems that demo videos recorded in real scenarios have better effects than animations or images.

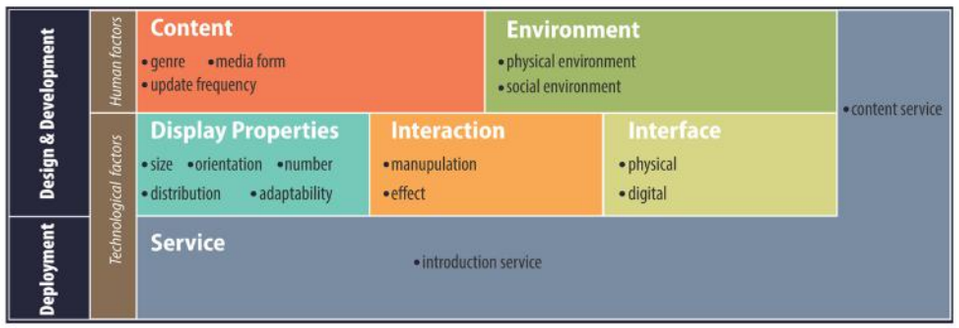


Figure 8-1 A framework for the key factors that influence the engagement and social effects of IPDs in nursing homes

As shown in Figure 8-1, we conceptualize the key design factors as a framework to better inform the future research and design in this field. Since *content* and *environment* are more related to residents' personal and social life, they are classified as human factors that can be investigated via extensive context and user studies. *Display properties*, *interaction,* and *interface* are primarily determined by the system specifications. They are classified as technological factors and can be determined via various design activities. *Service* can be either or both human and technological factors, depending on how it was provided. In most cases, *content and content service*, *environment*, *display properties*, *interaction*, and *interface* need to be considered at the stage of design and development. The *introduction service* is mainly considered during the deployment. Overall, this framework and related recommendations can provide guidance on how to design an appropriate IPD system for nursing environments.

8.2.2 In Response to RQ2 - To what extent can nursing home residents accept and engage with IPDs?

In Chapter 1, we identified the opportunities to apply IPD systems in nursing homes for residents' social interaction. However, older adults have long been considered to have relatively low acceptance and capacity to use new technologies. Hence, before the technical development and deployment, it is important to understand to what extent nursing home residents would accept and engage with IPD systems. As mentioned in Chapter 2, there were few explorations that could provide references for future design in this field.

The presented studies generated deeper insights on nursing home residents' acceptance and engagement with IPD systems. In the case study of OutLook, residents' acceptance was mainly investigated through structured observations and interviews. We found OutLook was well accepted by general residents mainly because of its friendly form and beautiful content. Most residents were attracted to be actively engaged with the display by pressing the button to discover more content and functions. But in the later period of the deployment, we saw a significant decrease in the number of active users due to the lack of explicit updates of the content. Another important reason is that the selection of the environment didn't follow the daily habits of the residents who liked to watch outside views. These insights were utilized in the case study of R2S. Users' acceptance was initially investigated in the design process with residents and further validated through structure observations, questionnaires and interviews in the evaluations. We found general residents held very positive attitudes toward R2S because it is not only simple and friendly but also very practical to use. Besides, we found residents could engage with R2S in groups simultaneously, and the system could continuously support their interaction by updating content and presenting various media forms.

Based on our results, the general answer to this question can be concluded that with proper design, IPDs can be well accepted and actively adopted by residents. The key to higher acceptance is not to push the complexity of technology, but to promote practicability and reduce related barriers. For deeper engagement, the design and deployment of IPDs need to follow residents' related habits, apply low-effort interaction techniques

and enhance the diversity of displayed form and content. Additionally, our studies indicated that the success of IPD systems in nursing homes should not be only determined by residents' engagement levels. Apart from the above-mentioned factors, residents' engagement level can also be affected by non-design factors such as residents' physical/mental conditions, daily habits, personalities, and the roles that they usually play in public spaces, e.g., performer or spectator. We believe a good IPD system should be able to support residents to engage in their conformable level and freely transit between different levels.

8.2.3 In Response to RQ3 - To what extent can IPDs influence nursing home residents' social lives?

Given the prevalently inactive lifestyle stated in Chapter 1, our ultimate goal was to attract nursing home residents to go to their public spaces more often and engage in social interactions. However, it was unrealistic to directly monitor all residents' daily behaviors. Previous studies indicated that one of the main problems was the lack of engaging public facilities (Ice, 2002; Ouden et al., 2015). From the dramaturgical perspective, it was difficult for residents to maintain their impressions on others due to the limited activities to choose from. Therefore, the main objective of our evaluation was to test whether IPDs could make public care environments more engaging.

In this thesis, the effectiveness of IPDs for social interaction was mainly evaluated through open field trials. In the field trial of OutLook (Chapter 3), we found that although OutLook could attract more residents to come and stay in an area that used to be unpopular, the social effects were limited. Since the residents spent less time on active use, few social interactions were observed in the vicinity of OutLook. Besides, most residents claimed no obvious improvement in their social connectedness when using OutLook. R2S was designed guided by the identified factors and lessons learned from the case study of OutLook, and it was found to have significantly more impact on residents' social lives in public areas. The open field trial of R2S (Chapter 7) indicated that although R2S didn't significantly attract more residents and extend their social time because it was already installed in a popular area, it was frequently used and deeply integrated in residents' social

activities. By deploying R2S in different conditions, we surprisingly found it could even change some residents' long-term social habits. Besides, we found R2S could play various roles in their social lives in public areas including a companion for individuals, an inviter for passersby, and a conversation initiator, mediator or reactivator for groups. Although the affective social benefits of using R2S were claimed to be obviously more than the costs, few residents felt significantly closer to others.

Based on the results, we can conclude that, even though nursing home residents' habits were difficult to change, we found that, with the full considerations of the factors mentioned above, IPDs can positively influence residents' social interaction or even change their social habits. Although such influence and changes might not be as significant as scheduled programs, IPDs can provide an open platform that continuously supports residents to manage their impressions in public spaces when no programs are organized. Besides, our studies indicated that the IPDs aiming to promote residents' daily social interaction seemed to have limited effects on their relationships and feelings, which might need to be further investigated with various content, in more contexts and over a longer period of time.

8.2.4 In Response to RQ4 - How to involve nursing home residents to contribute to the design of IPDs for their social interaction?

As mentioned in Chapter 1, designing IPDs for nursing home residents could be very challenging due to the digital divide and lack of mutual understanding. Previous literature mentioned in Chapter 2 identified the necessity and feasibility of involving users when designing social technologies for older adults. We also found that the specific process and methods usually vary with the designed technologies and contexts. However, to our knowledge, so far, few studies have explored how to involve nursing home residents in the design process of IPD systems for their social interaction.

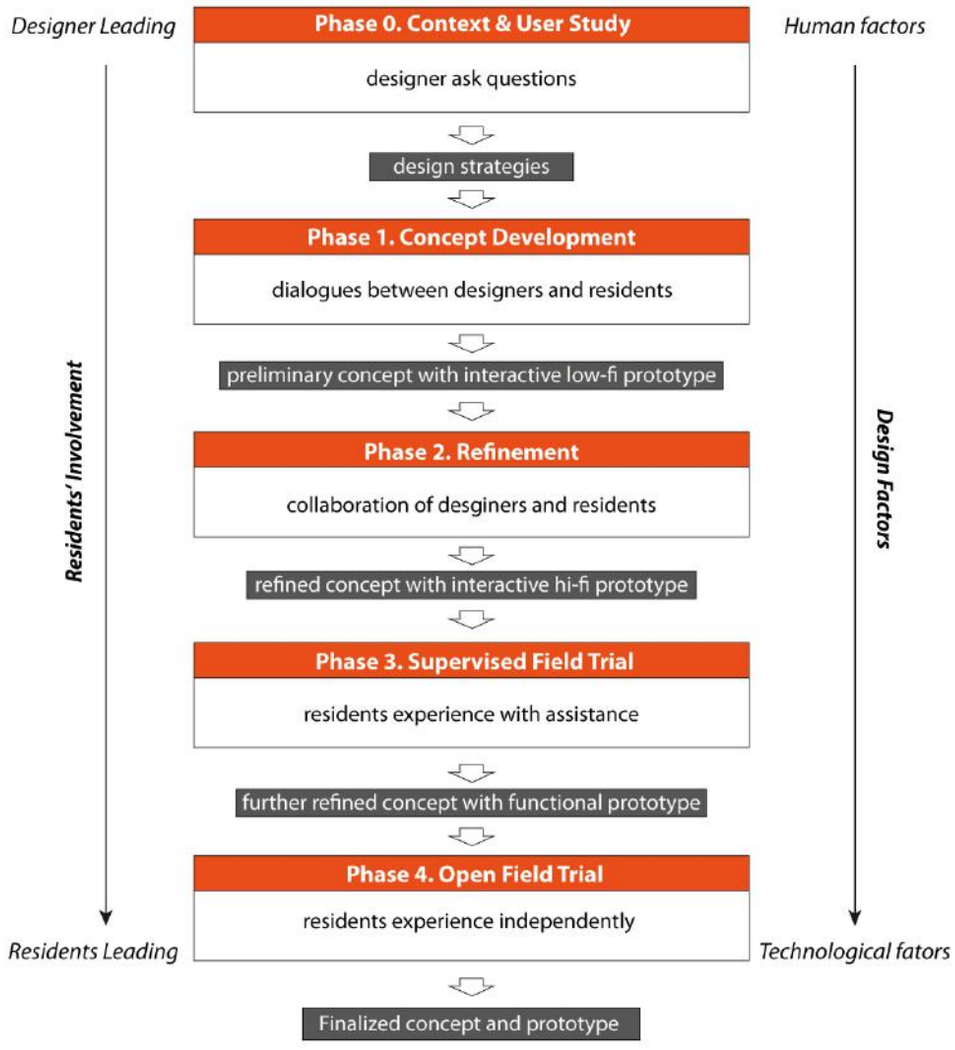


Figure 8-2 The SEESAW process model is proposed to guide how to involve nursing home residents in designing IPD systems for their social interaction

In the section above, we summarized the key design factors of IPDs for nursing home residents' social interaction. Based on our reflections from designing OutLook and R2S, deeper insights can be generated on how to involve residents to contribute to these factors. These insights were integrated into a process model aiming to provide guidance on how to involve nursing home residents in designing IPD systems for their social interaction. The construction of this model was mainly based on the USAP design model

(Demirbilek and Demirkan, 2004) and our reflections in this thesis. As shown in Figure 8-2, the process model consists of five key phases: *Context and User Study*, *Concept Development*, *Refinement*, *Supervised Field Trial*, and *Open Field Trial*. Generally, residents should be involved in all the phases. Design insights and requirements can be generated from each phase and validated in the following phases. *Phase 0* is the preparatory phase before the formal designing. Extensive inquiries should be conducted to understand the context and users before actually developing a concept. Design strategies can be made to identify the potential environments, genres and media forms of the content to display. In *Phase 1*, designers follow the strategies to develop design concepts through active dialogues with residents. Besides validating existing insights, residents can also contribute design requirements on display properties, which can guide designers to develop preliminary design concepts and interactive low-fi prototypes. In *Phase 2*, designers collaborate with residents mainly to refine the concept on physical interfaces and manipulations, which help designers refine the concept and prototype. In *Phase 3*, residents are invited to use the prototype system with designers' assistance. Their reactions and feedback can contribute to further refinement, especially on the digital interface and feedback. In *Phase 4*, fully functional IPDs are developed and deployed in the targeted environment for residents to use freely. Besides the system, the related services can be established and tested in this phase.

As shown in Figure 8-2, residents should be involved throughout the design process of IPDs. However, given the challenges for older adults to design new technologies, designers need to play a leading role in the early phases when the concept is vague, and the prototype has not been fully constructed. Residents can first contribute to their familiar human-related factors (e.g., environment, content) mainly through their voices. In these stages, we suggest involving residents individually for deeper conversations. As the design comes into shape, residents can be increasingly involved. They can join groups organized by designers or even formed by themselves. Hence, they are able to contribute to more technological factors (e.g., display properties, interaction, interfaces), not only through their voices but also their behaviors. Therefore, we believe different design phases require different degrees and forms of residents' involvement, which could contribute to different aspects of IPD systems.

Based on above mentioned, our model describes a process where residents' degree of involvement gradually increases while designers slowly fade away from the design activities. It is also a process of exploring from human to more technological factors. While in most design practices, designers usually experience an iterative process where the emphasis dynamically shift up and down between the two ends of the involvement and factors, which resembles the movement of a seesaw. Therefore, we called this the SEESAW process model. We hope that, with more future validations, the coverage of the model can be adapted and extended to involving older adults in designing other kinds of public socio-technical systems, and the implications of the specific techniques and methods adopted in each phase can guide future design in similar contexts.

8.3 Summary of Contributions

(1) Firstly, the basic contribution of this thesis is that it provides a deeper understanding of nursing home residents' social demands, preferences and barriers, which can inform the design of socio-technical interventions in care environments. (2) Secondly, we present the design and development of R2S. To our knowledge so far, although it still has room for improvement, it is one of the first socio-technical systems that can be independently used by residents and continuously support their meaningful activities throughout the day. (3) Thirdly, through the design and evaluation of the two cases: OutLook and R2S, we confirmed our assumption that IPD systems can not only be accepted and adopted by residents but also be a new form of intervention to alleviate the social problem in nursing homes. Furthermore, our studies conceptualize the interaction patterns between residents and IPDs and the social roles that IPDs can play in residents' daily lives (Chapter 7), which can further contribute to the design and HCI community. (4) Fourthly, we propose a framework that lists the six key design factors (***content, environment, display properties, interface, interaction, and service***) that can highly influence the acceptance, engagement and social impact of IPD systems for nursing home residents' social interaction. Related design implications and recommendations on each factor are also provided to inform future design. (5) Last but not least, the SEESAW process model is developed based on our reflections to give instructions for designers on how to involve residents in the design process to contribute to the key factors.

8.4 Limitation & Future Work

As mentioned in Chapter 2, all the studies in this thesis was conducted in the context of contemporary Dutch society. Although the global population is ageing, and many countries is introducing similar elderly care policies to what is implemented in the Netherlands, the adaptability of our results to other culture contexts still needs to be further investigated. Apart from the cultural bias, the limitations of our research in this thesis mainly lie in the field studies. As regards the supervised field study, although we tried to minimize the Hawthorne Effect, the result might be more or less influenced by the on-site supervision and video recording. However, we believe the collected data could still provide valuable insights for preliminary evaluation. Secondly, the results and findings of the supervised field trial might be affected by the participants' familiarity and interaction time. Since all the participants used R2S for the first time, their ratings and behaviors could be influenced by the individual differences in their acceptance and prior experience of using technology. Thirdly, since residents joined the supervised field trial in different groups, the results obtained may be biased by the group size, composition and their mutual relationships, which needs to be further validated with a larger sample. Regarding open field studies, limitations are mainly related to the sample and the period of the intervention. Firstly, it was difficult to control the size and types of the sample because the systems were installed in an open environment for residents to use freely. To avoid intervene residents' behavior, the participants were found after the intervention, which was easy to lead to an incomplete sample of users. Besides, we had to admit the fact that the public areas in nursing homes are regularly used by a small proportion of the whole population, which was a very common situation reported in numerous prior studies. Although we tried to reach more residents, the effects of our measures were very limited. Given their inactive lifestyles, the residents who usually stay in their rooms need a much longer period to be aware, accept and adopt such systems. However, although R2S was adopted by a relatively small population, this study still provided significant insights, and some participants were very representative. Secondly, the results might be restricted by the length of the intervention. Due to some budget and maintenance requirements, our intervention was conducted based on weeks, our observation lasted two hours per day and the system didn't run throughout the day, which should be extended in the

future. Additionally, although we believe content is part of the design of IPD systems, sometimes it was difficult to rule out the possibility that the user experience and social effects might be influenced by the content selection, which was almost inevitable in many studies of public displays.

Given the limitations, in future studies, the knowledge and design developed from this thesis need to be further validated. More studies are needed to explore more effective ways by humans or technology to enhance residents' awareness of the things in public spaces. The functionality and related services of the proposed design need to be further refined via more extensive field studies. Firstly, more units can be deployed to investigate the social effects not only within each unit but also between different units. More functions and interactions might be identified to connect different social groups. Secondly, IPD systems can be configured to run throughout the day to further investigate the interaction patterns and social effects of IPDs in different periods. Thirdly, further study is needed to conduct interventions for a monthly-based period to explore whether the system would gradually affect the residents who rarely go to public areas. Fourthly, more various content, media forms and technologies need to be tested to minimize related limitations. In this thesis, we mainly followed the first design strategy generated from Chapter 4 that mainly aims to promote residents' social interaction, which could explain the effects of our design on residents' social connectedness and relationships were found to be limited. In the future, since new generations of nursing home residents will have increasing acceptance and ability to use novel technologies, more efforts can be put into other strategies that focus on increasing residents' social quality and mutual relationships. Additionally, with the proliferation of emerging technologies such as artificial intelligence and machine learning, we believe they have great potential to be integrated into IPD systems in nursing homes to play a more important role in residents' social lives if they can gradually learn residents' preferences, regular routines and display corresponding content, which is also a promising direction to explore in the future.

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Appendix

A. The AttrakDiff-Short questionnaire

AttrakDiff-Short questionnaire (Dutch / English)

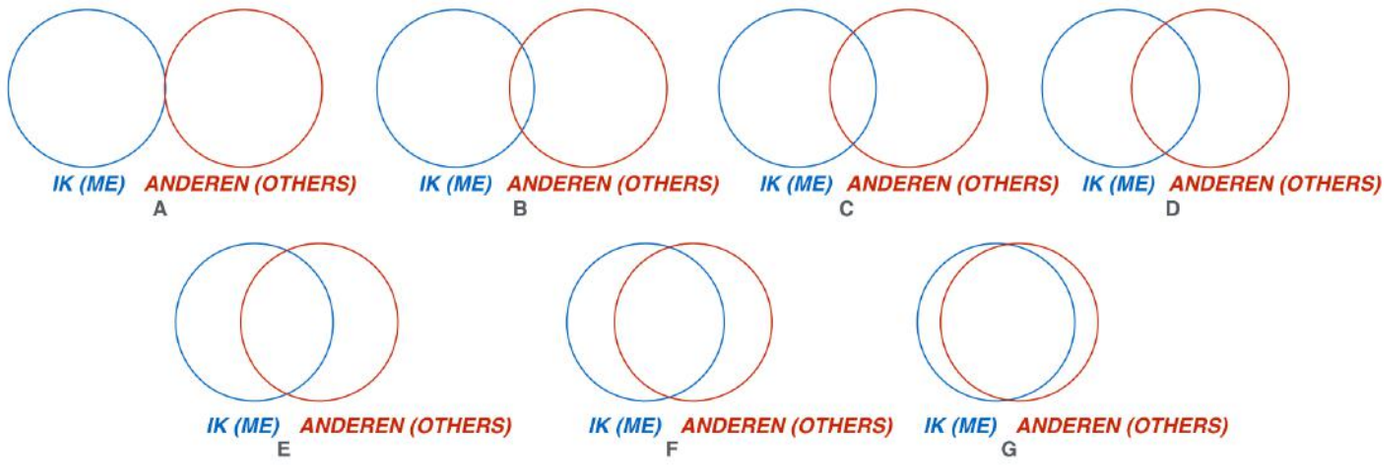
Volgens uw mening is dit ontwerp / In your opinion, this design is:

Eenvoudig / simple	○	○	○	○	○	○	○	Ingewikkeld / complicated
Praktisch / practical	○	○	○	○	○	○	○	Onpraktisch / impractical
Lelijk / ugly	○	○	○	○	○	○	○	Mooi / attractive
Voorspelbaar / predictable	○	○	○	○	○	○	○	Onvoorspelbaar / unpredictable
Stijlloos / tacky	○	○	○	○	○	○	○	Stijlvol / stylish
Minderwaardig / cheap	○	○	○	○	○	○	○	Waardevol / premium
Creatief / creative	○	○	○	○	○	○	○	Fantasieloos / unimaginative
Slecht / bad	○	○	○	○	○	○	○	Goed / good
Overzichtelijk / clear	○	○	○	○	○	○	○	Verwarrend / confusing
Saai / dull	○	○	○	○	○	○	○	Fascinerend / captivating

B. The Inclusion of the Other in the Self (IOS) Scale

If the blue circle represents you and the red circle represents other residents

*Please choose the picture below which best describes how close you are feeling to other residents sitting with you **now (pre-trial) / After using the design (post-trial)**?*



C. The invitation sent to the residents in the open field study of R2S

D. The UEQ-S questionnaire

Volgens uw mening is dit ontwerp / In your opinion, this design is:

belemmerend / obstructive	○	○	○	○	○	○	○	ondersteunend / supportive
complex / complicated	○	○	○	○	○	○	○	eenvoudig / easy
inefficiënt / inefficient	○	○	○	○	○	○	○	efficiënt / efficient
verwarrend / confusing	○	○	○	○	○	○	○	overzichtelijk / clear
vervelend / boring	○	○	○	○	○	○	○	spannend / exciting
oninteressant / not interesting	○	○	○	○	○	○	○	interessant / interesting
conventioneel / conventional	○	○	○	○	○	○	○	origineel / inventive
gebruikelijk / usual	○	○	○	○	○	○	○	nieuw / leading edge

E. Social benefits and costs questions

- ***Benefit 1: Self-Expressiveness***

1. Do you think you can know others' preferences / interests by using the stamp / watching the screen?

2. Do you think you can let others know your preferences / interests by using the stamp / watching the screen?

3. Do you think you can further understand each other by using the stamp / watching the screen together?

- ***Benefit 2: Engagement & Playfulness***

1. Do you feel boring when using the stamp / watching the screen with others?

2. Do you feel excited about using the stamp / watching the screen with others?

3. Do you have fun when using the stamp / watching the screen with others?

- ***Benefit 3: Presence-in-Absence***

1. Do you feel closer to others after using the stamp / watching the screen together?

2. Have you kept thinking back after using the stamp / watching the screen with others?

3. Do you feel more connected to others after using the stamp / watching the screen together?

- ***Benefit 4: Opportunity for Social Support***

If the participants used the stamp:

1. Do you feel that you are special when using the stamp with others?

2. Do you feel that others are expecting your sharing when you were using the stamp?

3. Do you think using the stamp with others will help you feel better?

If the participants did not use the stamp (just watch):

1. Do you feel that you are special when watching the screen with others?

2. Do you feel others are sharing something to you when watching the screen with others?

3. Do you think watching the screen with others with others will help you feel better?

- ***Cost 1: Feeling Obligated***

1. Do you think you have to talk to others when using the stamp / watching the screen together even if you didn't want to?

2. Would you feel guilty if you did not react or talk to others when using the stamp / watching the screen together?

3. Do you think you have to react or talk to others when using the stamp / watching the screen together even if you did not want to?

- ***Cost 2: Unmet Expectations***

1. Do you feel sad if others weren't around you when you were using the stamp / watching the screen?

2. Do you feel sad when others took too long to respond you when you were using the stamp / watching the screen together?

3. Do you feel sad because others did not pay enough attention to you when you were using the stamp / watching the screen together?

- ***Cost 3: Threat to Privacy***

1. Would you be worried that others might learn something that you want to keep secret when you were using the stamp / watching the screen together?

2. Would you be worried about your privacy when you are using the stamp / watching the screen together?

3. Would you be worried that someone would overhear or see something from the screen that you share or watch with others at the table?

Publications

Journal Papers:

1. Kang, K., Lin, X., Li, C., Hu, J., Hengeveld, B., Hummels, C., & Rauterberg, M. (2018). Designing interactive public displays in caring environments: A case study of OutLook. Journal of Ambient Intelligence and Smart Environments, 10(6), 427-443.

2. Kang, K. (2019). Designing interactive public displays as a new form of social intervention in nursing homes. The Design Journal, 22(2), 213-223.

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归期岂烂漫，别意终感激。

"It is delightful to have a date of return.

About to be apart, finally I can express all my appreciations."

–杜甫 by Du Fu AD 758

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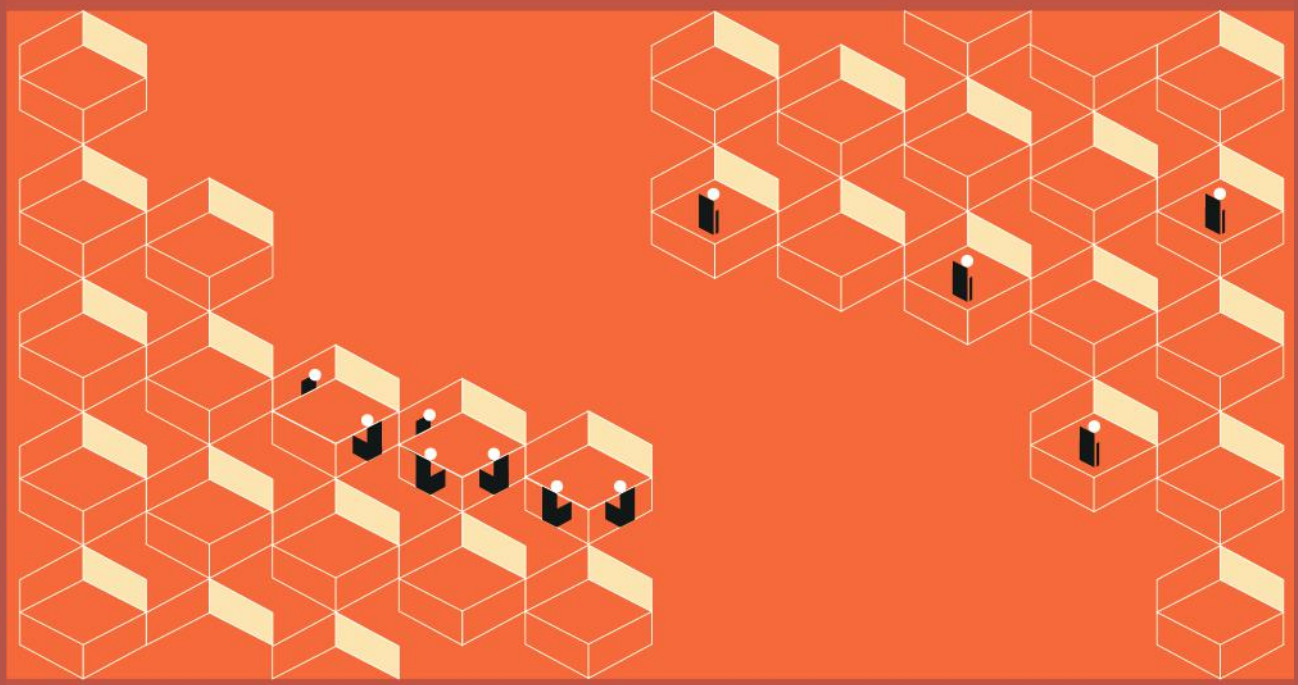
Curriculum Vitae

Kai Kang was born on September 19th, 1989, in Nantong, Jiangsu, China. In 2011, he received the bachelor's degree in Digital Media Technology at Jiangnan University, Wuxi, China. After which, he started his master program in Digital Media Art at the same university and received his master's degree in 2014. In 2015, he started his PhD research at the Department of Industrial Design, Eindhoven University of Technology, under the supervision of dr. Jun Hu, dr. Bart Hengeveld, and prof. dr. Caroline Hummels. His research interest lies in interactive public display, interactive installations, digital media, elderly care, and social interaction.

In 2020, Kai Kang moved back to his home city, living with his family. He is working at the Department of Industrial Design, School of Arts, Nantong University. Meanwhile, he co-founded "QingMai", a technology compnay aiming to develop products for sports, rehablitation, and elderly care.

The story is surely to be continued...



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