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Enhancing Social Interaction among Nursing Homes Residents with Interactive Public Display Systems

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ABSTRACT

Positive peer interaction in nursing homes has been consistently recognized as essential to residents' life quality. However, low rates of resident-to-resident interaction were found to be pervasive. Our research explores the potential of applying public display systems to promote residents' unplanned co-located interaction. This article describes the design and assessment of "Reading-to-Sharing" (R2S): a tabletop display system intended to improve nursing home residents' social interaction by enhancing their public reading experience. R2S was assessed via supervised field trials, in which the participants were invited to experience R2S in real-life settings with necessary assistance. The objectives were mainly to investigate the participants' engagement with R2S, user experience and the potential impact on residents' social behaviors and feelings. The result showed that R2S was capable of engaging the participants in content viewing and sharing. It was effective in catalyzing and facilitating their social interaction. The participants' perceived user experience was primarily favorable. Although R2S was anticipated to increase the participants' mutual closeness, no statistically significant change was seen. The key implications were highlighted to guide the design of public display systems in this context.

1. Introduction

Global population aging has led to increasing demands for high-quality specialized facilities and institutional care (Alders & Schut, 2019). Numerous nursing homes have sprung up in recent years to provide later life care for the aging population who can no longer live freely in their homes (Gillsjö et al., 2011). However, nursing homes are often characterized as places where residents suffer from solitude and social isolation owing to decreased social interaction with family and a lack of care resources (Kayser-Jones et al., 2003). Even though good social interactions among residents have been recognized as a crucial predictor of their overall wellness (Street & Burge, 2012), many studies revealed that most residents still spent a significant amount of time alone and inactive in their individual rooms (Gottesman & Bourestom, 1974; Ice, 2002; Ouden et al., 2015).

The most common method of encouraging inhabitants to engage socially was organizing various events in public places (Björk et al., 2017). Despite the fact that such an approach proved to be successful (Björk et al., 2017), it had several drawbacks. For starters, owing to time, money, and personnel limitations, maintaining the frequency was challenging (Mansbach et al., 2017). Second, such events could not be conducted continuously throughout the day (Ice, 2002), resulting in a lack of consistent impact on the emotions and actions of residents. Third, even though the topics of most events were specifically chosen to appeal to older persons, it was still difficult to cater to residents' diverse interests (Leone et al., 2012). Additionally, the researchers discovered that unofficial and unscheduled activities were the primary means through which social connections between residents were formed and maintained (Roberts & Bowers, 2015). Providing social chances were seen as more essential than enforced sociability (Claessens, 2013). As a result, according to Ice (2015), more engaging public care facilities and settings are required to enhance residents' social contact and assist them in their meaningful activities throughout the day. Furthermore, it is worth mentioning that the need for encouraging social connection amongst insiders becomes much more pressing during the COVID-19 lockdown due to the prohibition on most outside visitors entering the facility (Simard & Volicer, 2020). Nursing home residents were reported to be experiencing increasing despair and anxiety, deteriorating dementia, and failure to flourish due to the continued limitations (Abbasi, 2020).

As a result of the fast advancement of display technology and the growing prominence of multimedia content, we have seen an explosion of digital displays in various public places. The development of sensor technology, professional networking technology, and information technology has resulted in public displays becoming more engaging to attract individuals in their immediate area and encourage their mutual social engagement (Beyer et al., 2014; Prante et al., 2003; Wouters et al., 2016). Older users, on the other hand, have long been underrepresented in this industry. The development and deployment of relevant applications are rare, particularly among institutionalized older people (Stevenson et al., 2000). As a result, our study was driven by the need to investigate a potential form of public display

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technologies in nursing homes and understand how residents might utilize such systems to encourage social interaction.

In this paper, we present the design of "Reading-to-Sharing" (R2S) – a tabletop display system aiming to enhance residents' social interaction through augmenting their reading experience in public care environments. R2S was evaluated via a series of supervised field trial sessions to investigate residents' engagement with R2S, user experience and the potential impact on their social behaviors and feelings. The knowledge gleaned from the results may potentially be used to inform the design of public display systems for nursing home residents to foster social contact.

2. Related work

Over the last several years, a developing body of multidisciplinary study focused on what types of technology and how the technologies might assist older people's social activities in the face of physical, cognitive, and mobility difficulties. By adopting the categorization from computer-mediated communication research (Tong & Walther, 2011), Baez et al. (2019) recognized two research and design tendencies in this sector: *technology for virtual participation* (i.e., communication across a distance) and *technology for co-located participation* (i.e., face-to-face). We examined previous studies in the context of aged-care settings based on this categorization, and they are characterized as follows:

2.1. Technology for virtual interaction in nursing home

The proportion of loneliness among older adults in nursing facilities is considerably higher than that of community-dwelling populations since their chances to travel and engage in social activities are frequently limited by management policies and physical degradation (Victor, 2012). As a result, different types of virtual interaction technologies have been developed to overcome geographical and physical limitations.

These innovations were mostly applied in the private rooms of residents. One typical form was ICT applications that allow residents to connect directly with relatives or close friends who live at a distance (Vutborg et al., 2010). The effectiveness of such applications highly depended on the availability of residents' stable social partners, which could indicate why other research found no significant improvements or even negative effects (Woodward et al., 2011). Another goal was to encourage residents to engage online using social networking technology. Various platforms (Báez et al., 2016; Hutto & Bell, 2014) were developed to encourage individuals to engage in online groups, communities, and activities without leaving their rooms. Because the bulk of these systems need residents to actively utilize them, their acceptance and capacity to employ new technology may limit the social impacts. Given this, smart home technology and Ambient Intelligence (AmI) have been identified as potential solutions since they do not need residents to actively engage with the system. An ambient display or lighting system that constantly offered social awareness of residents' relatives, friends, or carers was a popular form in this domain (Biemans & Van Dijk, 2009; Dadlani et al., 2010; Davis et al., 2017).

2.2. Technology for co-located interaction in nursing home

Despite significant initiatives to achieve virtual contact among nursing home residents, face-to-face interaction was found to be more effective than other forms of socializing in preventing depression in later years (Teo et al., 2015). Moreover, Yuan et al. (2016) discovered that older individuals preferred in-person contact, but they frequently did not receive enough face-to-face interactions as they desired.

In recent years, a developing field of design and research that focused on how technology can enhance co-located interaction in nursing homes has emerged. The majority of this contact takes place between residents or between residents and their caretakers. The relevant study was further split into two sub-categories depending on different social situations. One branch was capable of facilitating scheduled social programs, while the other was responsible for supporting spontaneous social activities.

2.2.1. For organized social program

There has been particular attention in research on the role of technologies in organized social programs in nursing homes. Traditionally used technologies (such as TVs, computers, tablets, and other similar devices) have been extensively utilized in structured social activities because they are a common and practical form of technological innovation (Stevenson et al., 2000). But the majority were merely tools for caregivers to use in order to play media files. A growing desire to develop more engaging socio-technical applications for organized programs has evolved as a consequence. In order to increase residents' participation in structured activities, new technologies are increasingly being applied as alternative methods. Empirical research performed by Lin et al. (2018) discovered that residents who engaged with Virtual Reality (VR) material such as 360-degree movies, Google Street View, and guided tours reported feeling less socially isolated. Such programs have also shown the effectiveness of interactive tables and virtual worlds, although the vast majority of them were developed for people suffering from dementia (Astell et al., 2010; Descheneaux & Pigot, 2009; Feng et al., 2017; Good et al., 2019). Likewise, a few findings suggested that exergames (games with a remote control and motion sensors) could be used to promote residents' physical activities and encourage social interaction (Báez et al., 2016; Gerling et al., 2010), but such an intervention has relatively high requirements on residents' senses and motor skills (see Báez et al., 2016).

2.2.2. For unplanned social activity

Although many studies have shown the usefulness of technology in structured social programs (Báez et al., 2016; Gerling et al., 2010; Lin et al., 2018), such activities account for just a small portion of residents' daily activities (Mondaca et al., 2018). Research shows that residents spend more time informally participating in unanticipated activities and usually started by the residents themselves (Roberts & Bowers, 2015). Moreover, to the best knowledge so far, the role of technology in unplanned and unprompted actions has received much less attention than other topics.

One popular study area in this category is the development of socially assistive robots. "Paro," for example, was regarded as one

of the field's milestones. It was a baby seal-like robot that could provide companionship and social contact to eldercare facility residents (Šabanović et al., 2013). Paro had been designed to respond to certain stimuli, such as touch and light, and it was also capable of recognizing the terms that people often used to communicate with it. However, related studies found that nursing home residents were still hesitant about utilizing assistive social robots in open public settings without the help of others and that more research into the social functions of such robotic interventions is required (Abanovi et al., 2013; Chang et al., 2013).

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-Mansfield & Werner, 1998). With the proliferation of modern technologies, such multi-sensory environments were further explored using Mixed Reality (MR) technologies. The public displays, such as "The Virtual Forest" (Moyle et al., 2018) and "Closer to Nature" (Feng et al., 2017), primarily functioned as a content-assisting tool for animal-assisted-living therapy, memory therapy, and eco-therapy.

The display interventions for the residents without severe cognitive impairments were very limited. Existing typical cases were the "Photostroller" (Gaver et al., 2011), the "Community Display" (Nazzi & Sokoler, 2015), and the "OutLook (Kang, Lin, et al., 2018). Although these studies indicate that their display interventions were successful, none of them looked into how the interplay between usage and display systems affected social interaction among residents, and the resulting consequences were similarly restricted.

3. Design of R2S

3.1. Design rationale

Driven by what mentioned above, we designed R2S to support residents' unplanned co-located interaction, the concept of which was inspired by our previous field study (Kang, Lin, et al., 2018). We observed nursing home residents' daily behaviors by taking field notes. We found that reading in public areas was an important daily routine for many residents. However, due to physical and mental degradations, using print media products was becoming increasingly challenging for them (Smallfield et al., 2013). Moreover, the social impact of conventional print media was very limited because most print media products in nursing homes were utilized by individuals. Therefore, we assumed that proper digital augmentations would make print media more accessible and create more social opportunities.

3.2. Design process

R2S was developed through an iterative design process. We first conducted a preliminary study with 21 residents to investigate their preferred genres and related social demands (Kang, Hu, et al., 2018), then 14 residents were involved in 2 rounds of collaborative design to establish and refine the concept and prototype (Kang, Hu, et al., 2019).

3.3. Design concept

- System Overview

As shown in Figure 1, R2S consists of a series of tabletop display units distributed in public areas of nursing homes. Each unit of R2S consists of three parts: a tangible tool called IStamp, multiple specially designed stickers called IStickers and a digital display running 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. Digital information can not only reduce residents' physical barriers to reading, but also create more social opportunities by demonstrating media preferences and reducing the efforts of communication.7

- 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 attract residents. As shown in Figure 2, 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.

IStamp is a wireless device designed to recognize each ISticker and further interact with digital media. As shown in Figure 3, the appearance design of IStamp is inspired by conventional stamps. It is mainly composed of two parts. The square base makes it stand steadily on the table, and 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 3). 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 3). 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 4), which is helpful for the residents with sensory impairments.

- R2S Application

To run the system, each IStamp needs to be paired with one digital display running R2S application. The application has two modes: Edit Mode is designed for caregivers, and View Mode is for residents (Figure 5).

In Edit Mode, caregivers can add IStickers to the system by "stamping" on the stickers (Figure 6). After the codes of the stickers have been saved, caregivers can associate them to

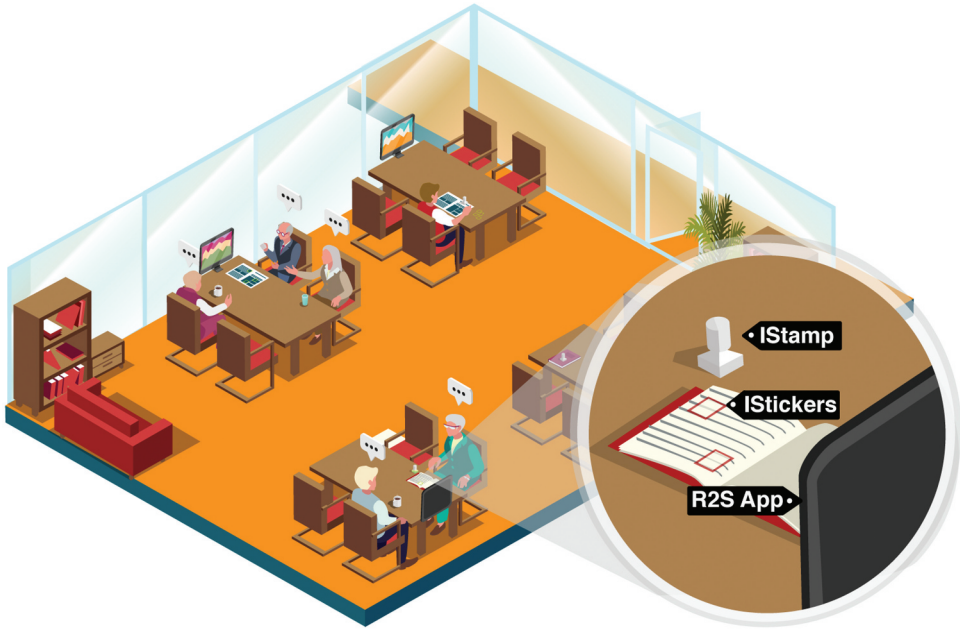

Figure 1. An envisioned scenario of applying R2S in a nursing home.

Figure 2. IStickers are used by caregivers to create interactive areas on print media products.

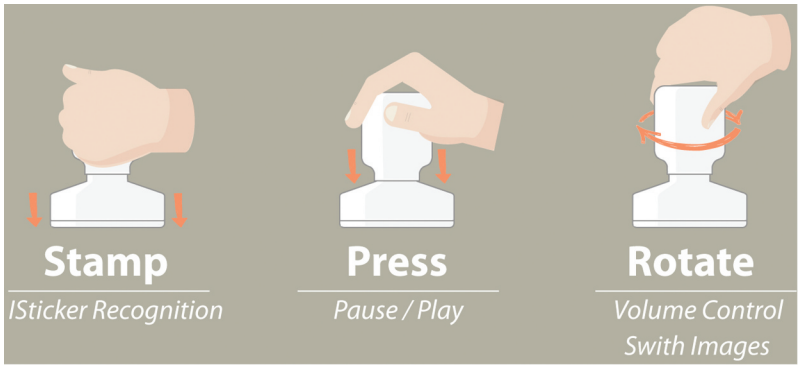

Figure 3. The basic and further interactions with IStamp.

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 View Mode and left on standby for residents' use (Figure 7). Once they "stamp" on the 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 8).

A prototype system of R2S was developed for evaluation. The implementation details were described in our previous report (Kang, Hengeveld, et al., 2019).

Figure 4. The visual and auditory feedbacks of IStamp are designed to facilitate older users.

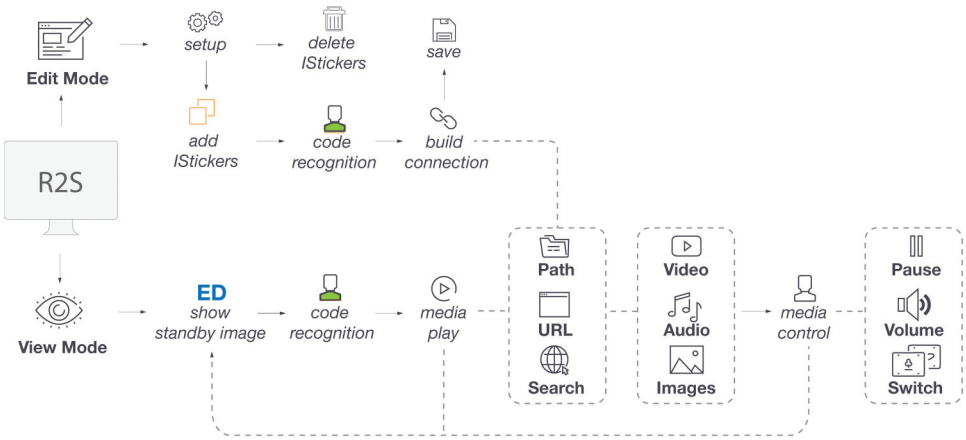

Figure 5. The R2S application has two modes. Edit Mode is mainly used by caregivers to build the connection between IStickers and digital information. Residents use View Mode to watch and control the digital information.

Figure 6. In Edit Mode, caregivers can quickly add IStickers to R2S system by "stamping."

Figure 7. In View Mode, R2S is left on standby for residents to use.

4. Evaluation

4.1. Objectives

We performed a series of supervised field trial sessions to assess the effectiveness of the prototype system R2S in fostering social interaction among nursing home residents. We assessed not only the social impacts but also the level of user engagement and user experience because numerous related previous studies showed that many older people had restricted acceptance and adoption of new social technologies (Abanovi et al., 2013; Chang et al., 2013; Gaver et al., 2011; Woodward et al., 2011). Moreover, we were interested in how residents' social interactions were impacted by their engagement with R2S, which may offer further design implications for similar display systems. The main goals of the evaluation were to examine the following three questions:

(1) How and to what extent would the participants engage with R2S?
(2) To what degree and in what ways can R2S influence the participants' social interactions?
(3) How would the participants perceive their user experience and social feelings after using R2S?

4.2. Methodological considerations

The assessment method was selected to be supervised field trials. Participants were invited to experience R2S in a real-life

Figure 8. The resident is sharing sports news and adjusting volume with IStamp to facilitate the communication with his social partner.

environment with the help of experimenters or care professionals if needed. This technique is a combination of the controlled laboratory experiment and the open field research, and it was selected with the following considerations:

In terms of the specificity of our target users, older people are often more reluctant to try new technology. Because R2S was still under development, the participants might run across usability or user experience issues, causing them to drop out halfway through. As a result, rather than leaving the design in an open environment, we preferred to let people experience it under supervision. Furthermore, although laboratory research has the benefit of being simpler to regulate in terms of equipment, environment, and procedure, we selected natural settings since many residents were limited in their movement and sensitive to changes in their surroundings. It is critical to establish a familiar and pleasant environment during the assessment.

In terms of study goals, we sought to observe, analyze, and characterize the participants' responses rather than control variables. As a result, for greater external validity, the assessment of the social impacts should take place in their familiar social contexts. Furthermore, we think that evaluating the user experience of older participants should take place during or shortly after the user trial, which necessitates the required controls from experimenters.

In terms of ethics, it was much more feasible to perform the study with invited residents instead of random people who were unaware of the experiment in public care environments.

4.3. Method

4.3.1. Participants

Participants were recruited from two Dutch nursing homes (Home A and Home B). Both are part of the same care company that has established more than twenty similar nursing facilities in Eindhoven. They were all equipped with rental flats and a variety of public areas. We did not have explicit inclusion requirements since most nursing homes often accept residents from various backgrounds (e.g., health problems, education, job), as long as they could openly voice their opinions.

As indicated in Figure 9, a total of 20 residents (9 men and 11 women) ranging in age from 70 to 102 took part in this research. During each of our visits, nine participants (4 men and 5 women) ranging in age from 70 to 89 were randomly invited in Home A's café. They were referred to as low-care participants because they were able to plan their social lives freely and visit the café at least three times each week. Eleven participants (5 men and 6 women, aged from 74 to 102) from Home B were recruited by care staff. Because of their physical degeneration, care staff arranged for them to participate in social activities in the café twice a week. They were labeled as high-care participants.

Since we wanted to assess R2S by replicating a common social scenario in nursing homes, the participants attended the trial sessions in small groups or pairs, much like they would in real life (shown in Figure 9). Because they were invited from the same social circle, the members in one group knew one other. Because both nursing facilities established independent areas and services for patients in the latter stages of dementia, all of our subjects had reasonably normal cognitive skills. Given many participants had difficulty reading or writing, consent was provided verbally before each session.

Besides the residents, we also spoke with four care employees (C1 and C2 from Home A and C3 and C4 from Home B) to get input from a third-party perspective. All of the care workers had more than five years of professional experience in the field of social care. Their responsibilities included a significant amount of planning social events for the inhabitants. They were asked to try out the system, compare it to their existing social interventions, and then provide their feedback on the system.

	Home A									Home B										
Group	G1			G2		G3		G4		G5				G6			G7			
Participant	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20
Gender	M	M	M	F	F	F	F	F	M	M	F	F	F	F	F	F	M	M	M	M
Age	70	72	77	71	83	81	83	87	89	82	74	89	102	78	84	96	88	92	87	91
LoR	3	5	3	2.5	9	2	7	3.5	3.5	5	5	7	6	1	0.5	6	0.75	2	0.5	0.5

Figure 9. Residents took part in the study in small groups or pairs. The following table contains their basic information. LoR means their duration of stay (in years) in their nursing homes.

4.3.2. Setup

The user trial sessions were carried out in the nursing homes where the participants lived. The management board gave its permission to conduct the research. During each of our visits, we performed each trial session with a different group of residents. Because the low-care and high-care residents required different levels of care, the trial sessions in Home A were conducted by two experimenters, while the same two experimenters did those in Home B with the assistance of two care professionals.

To assess R2S, we simulated a typical situation where a group of residents sits at one public table in their nursing homes. Following consultation with the care staff, the experimenters placed R2S at a rectangle table (140*80 cm) inside the café. It is one of the most popular places and focuses on social activities in nursing homes (Figure 10). A recent issue of the local newspaper was placed on the table. One of the experimenters chose eight items from the newspaper to be augmented with IStickers. The information ranges from local to worldwide news. It also contains a variety of genres such as stories, sports, history, and music. At one end of the table, a 20-inch monitor was placed to show relevant digital material that was mirrored from a laptop running the R2S program (Figure 10). IStamp was strategically placed beside the newspaper. A video camera was put up nearby to capture the sessions.

4.3.3. Measurement

4.3.3.1. Engagement levels. The participants' engagement with R2S was mainly investigated through the video records of the experience sessions. We primarily used the *Passive Engagement, Active Engagement, and Discovery Model* (PACD) to determine the various degrees of engagement (Memarovic et al., 2012). Since the PACD model was developed mainly based on the analysis of a conventional large stand-alone public display in urban settings, we slightly modified it to fit our context. The modification was based on the Menorah Park Engagement Scale (MPES) (Judge et al., 2000) that was developed to assess engagement levels in day care patients.

Noninvolvement, Passive Engagement, Active Engagement, and *Discovery* are the four degrees of engagement in the adapted model. Staring into space or in another direction away from R2S was referred to as *Non-Engagement. Passive Engagement* refers to short and brief engagements with R2S or watching others using, for example, a newspaper or a screen. *Active Engagement* was characterized as longer or more concentrated engagements with R2S, whether via active reading/watching, basic user interaction such as stamping, or a mix of the first two behaviors. *Discovery* refers to participants' interaction to explore more content and application features, such as searching for new IStickers and experimenting with more functions and interactions with IStamp.

Figure 10. The participants were experiencing R2S with the presence of experimenters.

4.3.3.2. Social interaction levels. The impact of R2S on the participants' social interaction was also investigated through the video records. We categorized different degrees of social interaction mainly based on the Social Play Continuum (SPC) and its adapted versions in earlier studies (Broadhead, 2003; Jansen & Bekker, 2009).

In our modified model, the participants' social interactions were divided into four categories: *nonsocial Domain, Associative Domain, Social Domain*, and *Cooperative Domain*. The *nonsocial Domain (ND)* refers to the instances in which the participants were not paying attention to one another's actions. The *Associative Domain (AD)* is where the participants engage in one-way communication, such as watching or reading together without speaking, seeing peer(s) usage, self-talk, giving things but not being accepted, and imitation, among other activities. The *Social Domain (SD)* encompasses the most fundamental reciprocal verbal or physical interactions between the participants, such as different kinds of conversation, eye contact, and objects given and received by the players, among other things. The *Cooperative Domain (CD)* relates to more in-depth communication to accomplish shared objectives, such as giving and receiving physical or verbal assistance, recognizing and addressing issues together.

4.3.3.3. User experience. The user experience was mainly evaluated using the Dutch version of AttrakDiff-Short (Fischer et al., 2018). The questionnaire is made up of ten pairs of adjectives on a 7-point Likert scale clustering in three dimensions: *Pragmatic Quality (PQ), Attractiveness (ATT)*, and *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 (Frederiks et al., 2019; Pham & Theng, 2012).

4.3.3.4. Social feelings. The impact of R2S on the participants' social feelings was primarily investigated through the "Inclusion of the Other in the Self" (IOS) Scale (Gächter et al., 2015). It has been shown to be a psychologically significant and highly reliable indicator of a relationship's subjectively felt closeness (Cadieux et al., 2019). The scale is composed of one pictorial item represented by 7 pairs of Venn diagram-like circles. In comparison to the traditional textual form, prior research has shown that the graphical form can significantly minimize the effort required for older participants to complete surveys (Cadieux et al., 2019; Kang, Lin, et al., 2018; Kang, Hu, et al., 2019).

4.3.4. Procedure & data collection

The assessment lasted around eight weeks, and we visited the nursing homes about three times a week to invite participants, set up, and perform the trial sessions. Each session lasted approximately an hour and was conducted with a single group.

- Preparation (5 minutes)

To prepare for the study, the participants were greeted upon arrival and helped to choose a seat at the table. To simulate the inhabitants' everyday scenarios in the café, the participants were served with drinks and snacks (Figure 10). The experimenters briefly described the research goal, which invited residents to participate in and give feedback on a new system designed to provide a new public reading experience in nursing homes. Then, one of the experimenters read over the consent form with the participants and answered any questions they may have. It was emphasized to all the participants that their experience sessions would be video recorded with their permission. The participants who didn't want to be filmed could turn their back to the camera so that their behavioral data would not be recorded and analyzed. The camera would not be turned on if the whole group refused to be recorded. Moreover, they may experience as much as they wanted without feeling obliged to utilize the system, and all respondents could withdraw from the research at any moment if they had any discomfort.

- Before experience session (15 minutes)

After getting approval, informal interviews were performed to gather basic information from participants such as their age, duration of residence, information source, and frequency of going to the public spaces. The participants were then asked to complete the IOS Scale to evaluate their feelings of closeness with their tablemates. Upon completion, the experimenters demonstrated R2S by showing a 5-minute instructional video with simultaneous verbal explanations.

- Experience session (15 minutes)

After all of the participants said they understood the idea, they were provided with the prototype to freely experience the system as they would do in their everyday lives. If the participants consented, the experimenters switched on the camera and set R2S to view mode. They sat alongside them as group members, but they mostly served as viewers. They did not prompt the participants until they experienced difficulties, overlooked important features, or asked for assistance.

- After experience session (25 minutes)

The experimenters turned off the camera and assisted the participants to fill out the post-procedure questionnaires, which included the AttrakDiff-Short and IOS scales. Upon completion, semi-structured interviews were conducted in groups to collect their feedback. At the end of each session, each participant received a gift voucher as a sign of appreciation.

4.3.5. Data analysis

All the video records were imported to NVivo and analyzed by two independent researchers. Throughout the annotation process, each participant's behavior was coded in turn. A two-round method was employed since the participants' usage behaviors, and social behaviors often occurred at the same time, and some communications were unrelated to the system. The first round focused on coding each participant's interaction with R2S. Their use patterns were divided into four categories, as previously mentioned: *Non-Engagement, Passive Engagement, Active Engagement*, and *Discovery*. Based on the first round's results, the second phase was to annotate individual participants' social behaviors that happened while they were using R2S. *Nonsocial Domain, Associative Domain, Social Domain*, and *Cooperative Domain* were used to categorize their social behaviors. In addition to the participants' behaviors, the experimenters' assistive behaviors were also coded to identify potential usability issues. We used a duration-based method to determine the time spent in each behavior category. The length of each behavior was then expressed as a proportion of the overall experience time in each session.

The results of the AttrakDiff-Short questionnaire were transcribed into the company's online evaluation tool (http://www.attrakdiff.de) to evaluate the respondents' overall user experience on the three dimensions of *Pragmatic Quality (PQ), Attractiveness (ATT)*, and *Hedonic Quality (HQ)*.

The IOS Scale scores of the subjects were entered into Excel. The mean values of pre-trial and post-trial ratings were computed, and paired difference tests were used to see whether the means differed significantly.

The recordings of the interviews were transcribed and imported in NVivo. A single coder manually coded and evaluated the participants' responses using thematic methods (Welsh, 2002).

4.4. Result

All seven groups have completed the trial sessions at the conclusion of the study. Although we expected to video record all of the participants, we were only permitted to gather behavioral data from twelve people in five groups. P3 and P13 were apprehensive about being recorded, so they experienced with their backs to the camera. Due to privacy concerns, the participants in Groups 4 and 7 declined to be filmed. Despite this, all twenty participants' questionnaires and interview recordings were obtained.

4.4.1. Findings from observation

4.4.1.1. Usability issues. The videos demonstrated that R2S put very low demands on users' abilities and prior knowledge. We discovered that nearly all of the participants could rapidly pick up on the basic interaction and "stamp" on the stickers without our prompting after viewing the video instruction. When it came to more diverse interactions, the majority of them needed just a little instruction at first. When they gently rotated the handle but received no feedback, several participants believed they had misused the system. As a result, the rotary encoder's sensitivity may be increased. The identification of IStickers was found to be the most common prompt.

Because the newspaper was so densely packed with information and pictures, some participants seemed to have a difficult time finding the IStickers. Furthermore, we discovered that some participants preferred to grip the IStamp's base rather than the handle. They recommended that the IStamp could be made a bit larger to make it easier to grasp. Apart from that, there were no apparent usability problems noted.

4.4.1.2. Engagement levels. The participants' engagement levels with R2S are shown in Figure 11. The bar graph depicts the percentages of time spent in each category of R2S interaction by individual participants. It indicates that during most of their experience time (Mean = 66.48%), all participants were actively engaged in utilizing R2S. However, we noticed that the low-care (Home A) and high-care (Home B) participants used R2S in different ways. As shown in the table below, nine of the twelve individuals had directly engaged with the IStamp. All the participants who did not touch IStamp were from Home B. Furthermore, we discovered that the low-care individuals spent much more time using IStamp directly, with far less prompting from the experimenters. The majority of high-care individuals seemed to be warier about touching the interfaces. They would rather have the care workers, or experimenters activate the digital display and view the content. As a result, it's fair to assume that high-care participants' engagement would be considerably lower if they utilized it independently. The varied usage patterns may also explain why low-care individuals spent considerably more time exploring the system, while high-care participants were more passively engaged in R2S use.

4.4.1.3. Social interaction levels. Figure 12 shows the percentages of individual participants' time spent in each level of social interaction with their peer(s). It demonstrates that, while the distribution of social interaction levels varied across the groups, the majority of the respondents' social interactions fell into the social and associative domains. The average proportion of high-level social contact was 30.68% (SD = 0.14), which was substantially greater than the average percentage of nonsocial activities (paired t-test, p = .0103, power = 0.88), which was 14.32% (SD = 0.12). It showed that the participants spent a relatively high proportion of their time in mutual communications. With greater variation, the average proportion of medium-level social contact was somewhat lower (M = 29.68%, SD = 0.17). Furthermore, because all of the rich social interactions were only observed in Home A, it was easy to find that the average percentage of the cooperative domain was the lowest (M = 4.51%, SD = 0.05). This could be due to 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 discovered that high-care participants engaged in significantly more medium-level social interaction than low-care participants (paired t-test, p = .013, power = 0.74), with average percentages of 40.77% (SD = 0.13) and 18.59% (SD = 0.12), respectively, which could be due to the high-care participants' passive engagement with R2S. In addition, although the average percentage of high-level social contact in Home A (36.46%, SD = 0.16) was greater than in Home B (24.89%, SD = 0.12), low-care participants exhibited a slightly higher average proportion of nonsocial activity (MA = 16.78%,

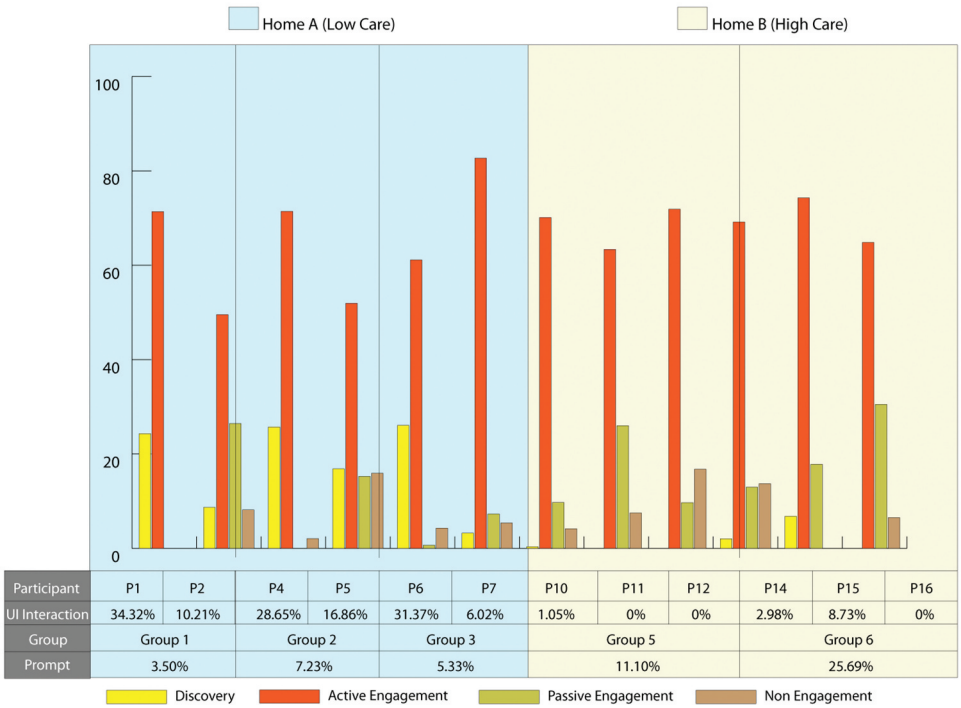

Figure 11. The bar graph illustrates the percentages of individual participants' time spent in each category of engagement with R2S. (The value of the bar = Participants' time spent in each level of engagement with R2S (min)/Participants' experience period (min)); The table below shows the percentage of individual participants' time spent in directly using IStamp and being prompted (UI Interaction = Participants' time spent in directly using IStamp (min)/Participants' experience period (min); Prompt = The period when participants needed assistance (min)/Participants' experience period (min)).

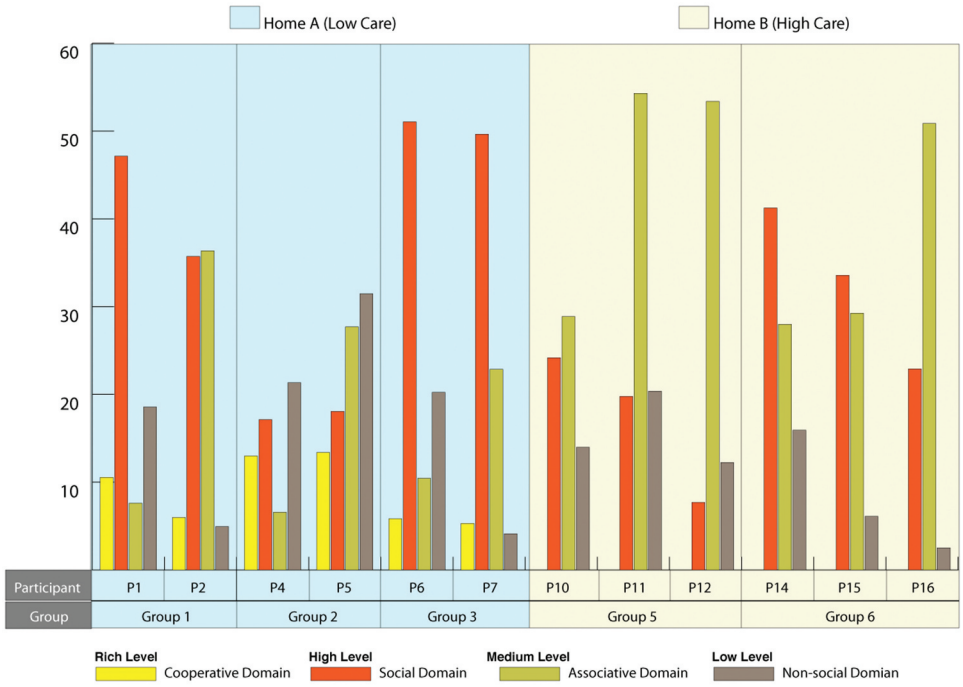

Figure 12. The bar graph shows the percentages of individual participants' time spent in each level of social interaction with their peer(s) (The value of the bar = Participants' time spent in each level of social interaction caused by using R2S (min)/Participants' experience period (min)).

SDA = 0.11; MB = 11.86, SDB = 0.07). In each of these areas, no relevance was discovered.

4.4.1.4. Engagement patterns in social domains. To investigate how the use of R2S might impact residents' social interaction, the percentage of individual participants' social time in each domain spent simultaneously with the various degrees of engagement was measured. As shown in Figure 13, the darker color of the stacked column indicates a greater degree of interaction with R2S. Ultimately, we discovered that the degree of social contact rose as the participants were more engaged with R2S, indicating that the prospective social impact of R2S on the respondents' behavior was favorable.

To better understand the connection between system characteristics and their social impacts, the two coders assessed the participants' usage patterns in each social domain. The inter-rater dependability was calculated to be 82% (percent agreement), indicating that there was a high level of agreement generally. Following the separate coding, a single coder categorized all of the patterns and merged the findings in the following manner:

Cooperative domain. All the rich social interactions took place when the participants were discovering or actively using R2S. ***Collaborative exploration*** of system features, or content was the most frequent engagement in this domain. Although the augmented newspaper was intended mainly for primary operators to preview material, we discovered that other group members might be actively engaged in this activity as well, e.g., they looked through the newspaper jointly to find out what could be in it, or they tried the IStamp together to see how it worked. ***Collaborative problem solving*** was discovered when the group members had difficulties in using the system, e.g., they reminded each other when they couldn't find the interactive areas. Another frequent pattern of engagement was ***social learning***. It was caused mainly by the participants' varying levels of knowledge of the system. Teaching/learning activities were often reported in this category. Some participants with more assertive personalities go so far as to brag about themselves or encourage and lead others to use.

Social domain. As previously stated, various forms of conversations were essential components of high-level social interactions. The great majority of the interactions captured in this domain occurred when the participants were actively using R2S, as shown in Figure 13. We discovered that most annotated social contact in this area was ***mediated discussion*** initiated and sustained by shared displays. These conversations were often accompanied by bodily gestures like pointing to the media material. Furthermore, we found a vast majority of such communications were mediated by the videos. One of the most frequent situations was watching and commenting on video material without making eye contact. They often started the conversations by focusing on the details in the video such as a particular item, person, or place. Conversations mediated by printed material or digital pictures were often recorded as well, although they didn't appear to continue very long. Even though ***direct conversation*** is a standard mode of communication, direct talks were captured much less often. They were mostly occured around or after the conclusion of each displayed item, if the topics were expanded to their tales, shared knowledge, or jokes. Physical expressions like eye contact, acting, and smiling were often used in these interactions.

Associative domain. Besides the social domain, the associative domain was another major category that we observed (shown in Figure 12). Figure 13 shows that active and passive

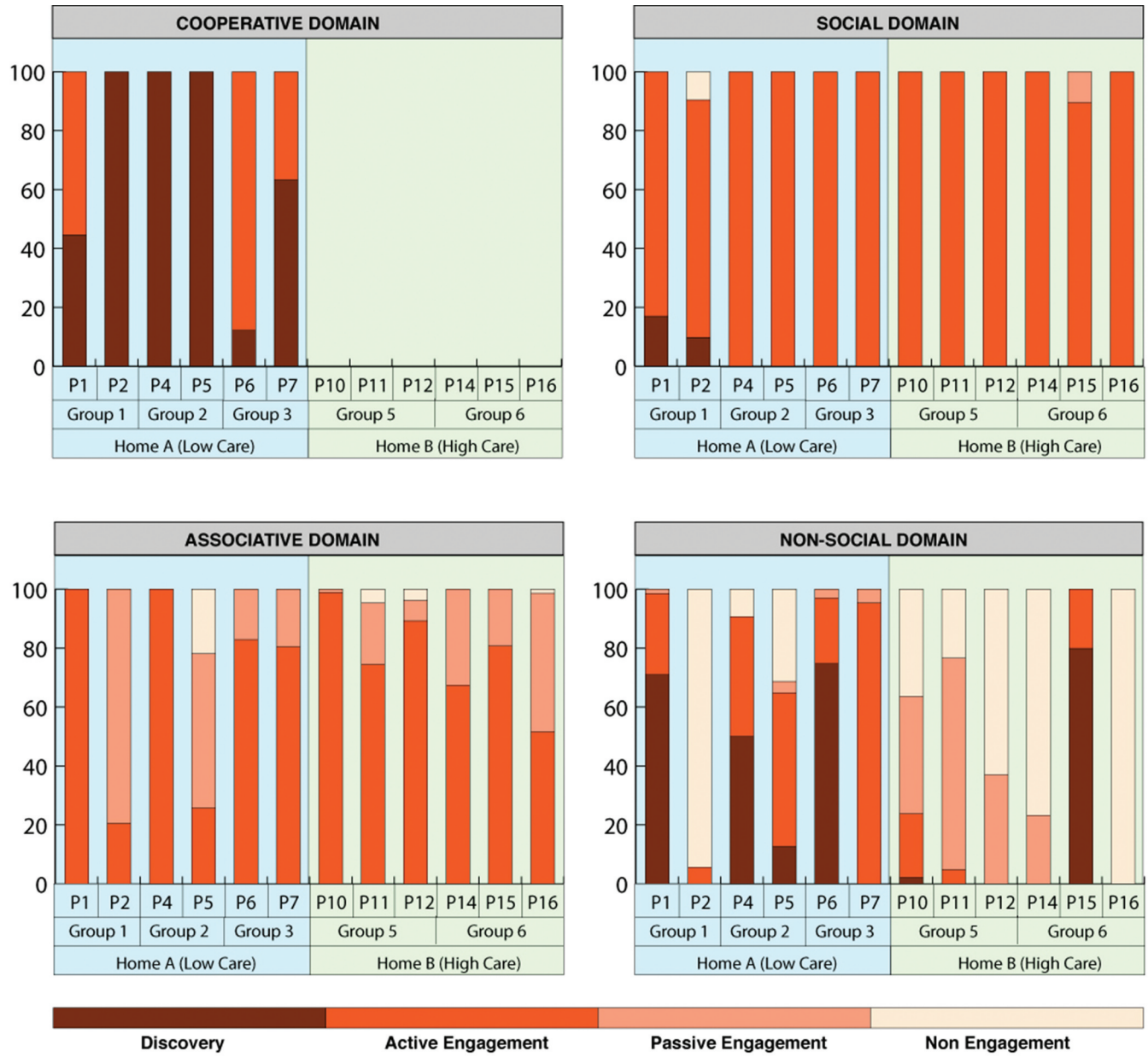

Figure 13. The stacked bar charts show how different levels of R2S engagement affected individual participants' social interactions in different domains (the volume of each column = Participant's time spent in each level of R2S (min)/Participants' social time in each domain caused by using R2S (min); the darker color of the columns represents deeper R2S engagement).

engagement was the most common degrees of concurrent engagement with R2S. When the participants were actively engaged, the most frequent medium-level contact was ***watching together***, which was a common method for group members to bond. Associative reading was also seen occasionally, but only in Home A and only a tiny proportion of the time. It mostly happened when the participants expressed a strong interest in the displayed material and demanded additional information from the articles. When their group mates were engaged in other activities or disengaged, we discovered that some individuals preferred to ***watch alone with self-talk. Observing others*** was shown to be the most common medium-level social contact when the participants were passively engaged. It was done mainly by those who didn't utilize IStamp directly. If some participants did not have enough motivation to join the primary operator in exploring the content, they tended to passively observe.

Nonsocial domain. Figure 13 shows that nonsocial situations may occur at any degree of engagement, complicating the compositions of the stacked columns in the nonsocial Domain. We've outlined three everyday situations. First, one participant's social behavior may cease when they are disengaged from group usage, usually because of being ***distracted*** by the external environment or other unrelated activities such as eating/drinking. Second, the nonsocial situations could also happen in ***parallel use with different attention***, e.g., some participants were reading newspaper while others were watching the display. Third, we discovered that occasionally ***the highly-focused usage*** might lead to nonsocial circumstances, such as when certain leading

operators are concentrated on reading the material alone and fail to engage others.

4.4.2. Result of questionnaire

4.4.2.1. User experience. Figure 14 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 that the R2S prototype was compelling and appealing overall. However, the prototype was only rated as average on the Pragmatic Quality (PQ = 0.33) dimension, which implies that usability could be improved., and we did identify some usability issues through annotating the experimenters' prompts.

Figure 15 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 rated as a clearly structured, stylish, premium, creative, captivating, attractive and good system. Complexity and unpredictability are the significant issues with the user experience, according to the extreme negative side.

In light of the video data identifying the distinct modes of interaction between the low and high-care participants, we went on to examine the participants' perceptions of their perceived user experience respectively. As shown in Figure 16, both of their ratings on the HQ and ATT dimension were located in the above-average region, confirming that participants with low and high levels of care felt the prototype was attractive and pleasing to use.

According to the mean values of the word pairs, as shown in Figure 17, the low-care individuals ranked them somewhat higher on virtually every item 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

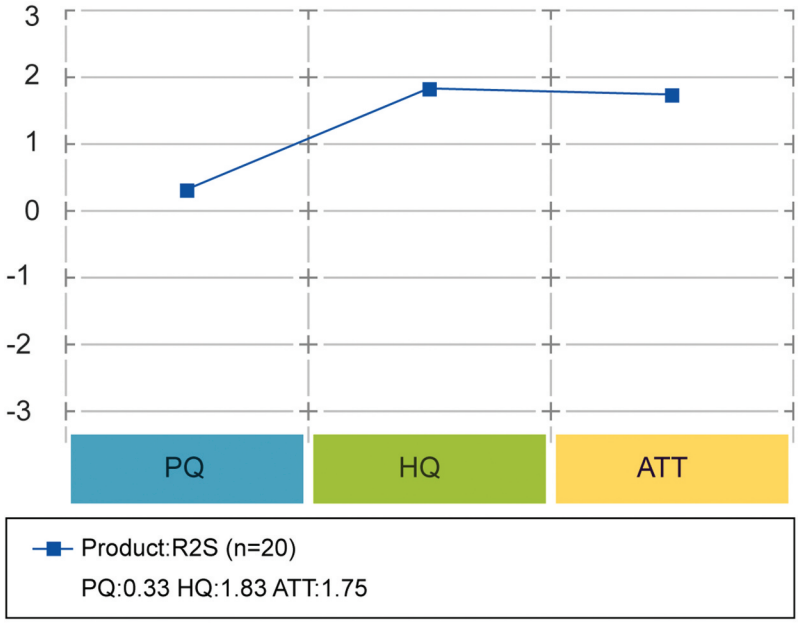

Figure 14. The average values of the three dimensions on the AttrakDiff-Short questionnaire.

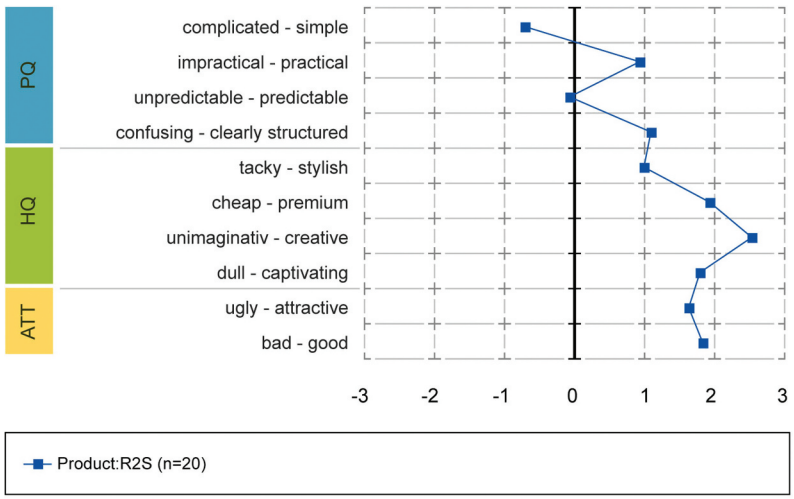

Figure 15. The description of word-pairs in the AttrakDiff-Short questionnaire.

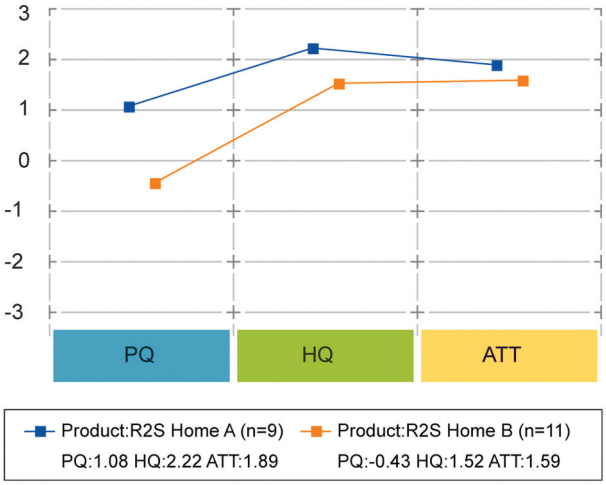

Figure 16. The average values of the three dimensions on the AttrakDiff-Short questionnaire rated by the participants from Home A and Home B respectively.

participants (below the average). We found that both low-care and high-care participants thought R2S was practical, but the high-care participants were more likely to feel complicated, unpredictable and perplexing.

4.4.2.2. Closeness feelings. The mean IOS score before the experiment was 4.85 (standard deviation = 1.59), and it increased slightly to a mean of 4.9 (standard deviation = 1.67) after the trial. Since the IOS scores were not normally distributed (Shapiro Wilk test, $p < .05$), non-parametric statistical tests were applied. The Wilcoxon signed-rank test (also known as the paired sample rating test) was used to compare the IOS scores obtained before and after the experiment. Even though R2S was expected to make participants feel closer to one another, no statistically significant change was observed. ($Z = -0.25$, $p = .8$).

4.4.3. Interview result

4.4.3.1. Interview with the participants. All the participants expressed their gratitude for the combination of print and digital media. They believed that the system had reduced the technical bar for gaining access to new sources of 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) Nine participants expressed interest in the possibility that R2S might reduce the physical demand for reading. The majority of them were very enthusiastic about the future implementation in their public spaces, mainly because it offers up-to-date information and allows for more 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)

The input from the participants on their user experience matched the results of the AttrakDiff questionnaire. The overall user experience was highly praised. "*I have no problem in using it. It's not difficult. I don't have to think too hard.*" (Group 3, P7) 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 form of digital video, a better view to display information, the ability to provide updated topics, free of charge. The complexity indicated in the questionnaire mirrored the participants' concerns about the video instruction, which showed too much information. The unpredictability reflected in the questionnaire was mainly due to the fact that it was still a relatively new idea to them, particularly for specific high-care individuals.

In terms of social effects, all of the participants believed that utilizing R2S would improve their communication. "*Of course, it will trigger socializing. It is valuable to provide information for people to talk about.*" (P4, Group 2) However, only a few of them were able to articulate the impact of R2S on their emotions of intimacy. The majority of participants stated that they didn't see much of a change since it was their first time using it, and they only used it for a short time. This may explain why the IOS questionnaire's pre-trial and post-trial ratings changed so little.

4.4.3.2. Interview with the care workers. Following the video demonstration, all of the caregivers could rapidly grasp the

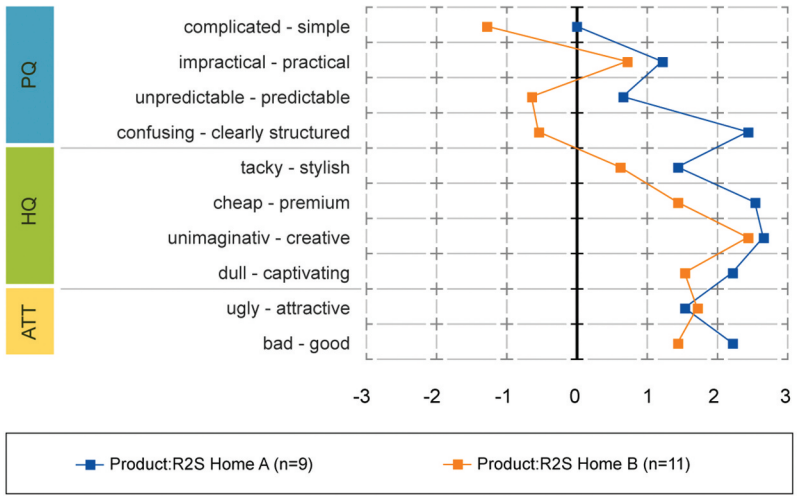

Figure 17. The description of word-pairs in the AttrakDiff-Short questionnaire rated by the participants from Home A and Home B respectively.

design idea and test the system without our assistance. They frequently remarked how pleasant and straightforward it was to use, especially for older users. C4 compared R2S with their "magic table" that was primarily intended for dementia patients to play projected tabletop games. They had to secure the gadget and operate it by experts since it was costly and complex. As a result, they liked R2S for being able to "freely turn the paper alive," which could provide new opportunities for their work. "*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 significant aspect they appreciated was the ease with which they could expand the system and the cheap maintenance cost. The future application piqued the interest of all the caregivers. Their primary concern was the acceptance and interest of the residents. Since the system was already extremely simple to use, they recommended that additional efforts should be made to encourage people to take the initial step. "*I am sure it is feasible. We will do this every day if they are interested in it.*" (C2)

5. Summary & discussion

This study showed that R2S was a success by our criteria in keeping the group members interested and, in particular, actively engaged in content sharing and viewing. Although our supervision may have impacted their engagement levels, particularly among high-care participants, the majority of them demonstrated that they have the capacity and desire to utilize such systems. The care workers pointed out that the high-care participants had been used to passively receiving information in such routine tasks for many years. Thus, it was understandable that they would need more time to break this habit.

In most instances, R2S enabled participants to engage in their preferred manner. R2S was intended to be a content-based platform controlled by one person and watched by others. Surprisingly, the participants demonstrated various and dynamic usage patterns. In general, each participant was free to select how to interact with R2S. However, we also identified some "engagement gaps" shortly before and after each display. Because of a lack of concern for indirect users, they frequently did nothing if they were reluctant or unable to join the operator, resulting in a greater chance of disengagement.

R2S showed much promise in terms of catalyzing social interactions among residents. The participants demonstrated a wide range of social interactions, which exceeded our expectations. In general, the results revealed that the participants' degrees of social interaction were favorably linked to their engagement levels. However, we also found that the participants' unfamiliarity may lead to intense usage, which could limit social possibilities. Furthermore, we discovered that the social benefits of R2S tended to diminish in bigger groups due to the presence of more non-operators who were more easily passively engaged or disengaged.

Using R2S was generally regarded as a pleasing experience by the participants. Most participants indicated a strong desire to utilize R2S in the future. However, there is still room for improvement in usability. The unfavorable remarks were primarily resulted from the participants' feelings of complexity and uncertainty. The complexity was partly due to the video instruction displaying superfluous information, which raised the cognitive load on the participants. Another important reason was related to the limitation of the organized experience sessions. Although R2S was designed in a simple form to realize the basic function with easy interaction, it was difficult for the participants to try out all of the functionalities in their first trial and in such a short amount of time. The complexity reflected in this research, according to their comments, was unlikely to be an issue in their actual everyday usage. The feelings of uncertainty were mainly expressed by the high-care individuals. The absence of information regarding interactive areas and the content to be displayed appeared to raise their effort to use. Although some low-care participants found searching for information fascinating, we think the system has to be enhanced to support general residents, particularly those in poorer physical or mental health.

Although R2S was designed primarily to promote nursing home residents' social interaction, we hypothesized that it could also impact their social feelings. However, no significant variations in felt closeness were found in questionnaires or interviews. It was partially due to the limitation of our measurement. Social feelings may include not only closeness, but also other dimensions such as perceived contact quality and shared understanding (Visser et al., 2011). Moreover, the interviews revealed that many other factors, such as the group's makeup, duration of usage, personal interests, and the displayed content, may affect their closeness of emotions. As a result, the impacts of R2S on the participants social feelings has to be explored further with diverse content, more extended experience, and more thorough measures.

6. Design implications

Although many implications were derived from this study, we primarily address the significant ones that may contribute to the design of public display systems for nursing facility residents' social interaction:

- Combine 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. This architecture was consistent with the transactional communication paradigm (Barnlund, 2008). The horizontal displays provide private cues. They may 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 act as public signals and may be designed bigger to broadcast the shared information to the social group. In this case, the newspaper served as a horizontal display due to our user groups' acceptance and ability to utilize new technologies. They found that flipping pages was a far more natural method to examine information, but it came with several drawbacks. Traditional print media products, for example, are unable to offer active feedback to assist older consumers. According to the care staff, the residents' ability was increasing as younger generations moved in, which

means there would be more opportunities to develop technology in such a display form in the future.

- Support continuous parallel use

R2S enabled participants to use in their preferred manner and, to some degree, supported simultaneous usage. However, the design of R2S, like other traditional interactive public displays, was centered on the direct operators. The majority of non-operators mainly served as observers. Due to a lack of concern for non-operators, the system was set up only to show a standby picture when the operators provided no data to avoid being invasive. During this time, many of them seemed impatient and preoccupied, resulting in decreased levels of engagement and, as a result, fewer social chances. Therefore, interactive public tabletop displays in nursing homes should be designed to appeal to both operators and non-operators. To prevent the "engagement gap," the systems must be able to sustain their ongoing concurrent usage.

- Design for diverse social interaction

In this study, the observed social interaction was divided into four tiers. Most socio-technical systems are built to encourage high-level social interactions such as collaborations and active discussions, which was precisely what we wanted to accomplish with R2S. However, the results and conclusions of this research showed that various degrees of social contact might benefit different individuals. Some residents who have had their communicational capabilities deteriorated, for example, may feel calmer and connected in moderate, mediated, or passive interactions than in intense, direct, and active discussions. R2S may even be utilized individually, according to some participants, so that they wouldn't feel humiliated in public. As a result, the sociability of public display systems should be assessed in terms of the number of triggered social encounters and their capacity to facilitate a variety of social interactions. If we relate socio-technical strategies to sports, we need to design systems like basketball that can be played alone, one on one, three on three, or five on five, rather than tennis, which typically needs partners to play with.

7. Limitations

A supervised field experiment was chosen based on our study participants, research goals, and ethical concerns. This approach was found to be acceptable by nursing home residents, effective in collecting objective and subjective data, and practicable for nursing home management in our research. It did, however, have certain limitations:

To begin with, despite our best efforts to minimize the Hawthorne Effect during the experience sessions (Sedgwick & Greenwood, 2015), on-site supervisions and video recording may have influenced the participants' natural user behavior and social interaction, implying that the results should be further validated in subsequent stages without researchers present.

Second, the familiarity and contact time of the participants may have an impact on the outcomes and conclusions. Individual variations in acceptance and previous experience of utilizing technology may have affected the participants' ratings and actions since they were all using R2S for the first time. The length of the user trial was reported to be sufficient for the participants to experience all of the functions and interactions. Some participants could no longer use the system because they appeared tired near the end of the sessions; however, the short period of interaction and single scenario may only provide us with essential interaction and social patterns, which must be further extended in long-term use in their daily lives.

Finally, the findings, as mentioned above, are based on a variety of small groups. The size and makeup of the group may skew the findings. Furthermore, the result's application to different situations (e.g., individuals or bigger groups) must be confirmed using a larger sample.

Furthermore, as previously stated, the displayed content was not the primary focus of the research. We chose news stories from a variety of categories. It was impossible to rule out the idea that the content selection, which was almost unavoidable in the assessment of public displays, impacted the user experience and societal consequences. To reduce this restriction, further assessments with different types of material are needed.

Disclosure statement

No potential conflict of interest was reported by the author(s).

References

Abbasi, J. (2020). *Social isolation—the other COVID-19 threat in nursing homes*. Jama.

Alders, P., & Schut, F. T. (2019). Trends in ageing and ageing-in-place and the future market for institutional care: Scenarios and policy implications. *Health Economics, Policy, and Law*, *14*(1), 82–100. https://doi.org/10.1017/S1744133118000129

Astell, A. J., Ellis, M. P., Bernardi, L., Alm, N., Dye, R., Gowans, G., & Campbell, J. (2010). Using a touch screen computer to support relationships between people with dementia and caregivers. *Interacting with Computers*, *22*(4), 267–275. https://doi.org/10.1016/j.intcom.2010.03.003

Báez, M., Ibarra, F., Far, I. K., Ferron, M., & Casati, F. (2016). Online group-exercises for older adults of different physical abilities. In *2016 International Conference on Collaboration Technologies and Systems (CTS)* (pp. 524–533). IEEE. https://doi.org/10.1109/CTS.2016.0098

Baez, M., Nielek, R., Casati, F., & Wierzbicki, A. (2019). Technologies for promoting social participation in later life. In B. B. Neves & F. Vetere (Eds.), *Ageing and digital technology* (pp. 285–306). Springer. https://doi.org/10.1007/978-981-13-3693-5_17

Barnlund, D. C. (2008). A transactional model of communication. In C. D. Mortensen (Eds.), *Communication Theory*, *2* (2nd ed., pp. 47–57). New Brunswick, NJ: Transaction. https://doi.org/10.4324/9781315080918-5

Beyer, G., Binder, V., Jäger, N., & Butz, A. (2014). The puppeteer display: Attracting and actively shaping the audience with an interactive public banner display. In *Proceedings of the 2014 conference on Designing interactive systems* (pp. 935–944). ACM Press. https://doi.org/10.1145/2598510.2598575

Biemans, M., & Van Dijk, B. (2009). Food for talk: Photo frames to support social connectedness for elderly people in a nursing home. In *Proceedings of the European Conference on Cognitive Ergonomics, VTT Technical Research Centre of Finland, Helsinki* (pp. 147–154). ACM Press.

Björk, S., Lindkvist, M., Wimo, A., Juthberg, C., Bergland, Å., & Edvardsson, D. (2017). Residents' engagement in everyday activities and its association with thriving in nursing homes. *Journal of*

Advanced Nursing, *73*(8), 1884–1895. https://doi.org/10.1111/jan.13275

Broadhead, P. (2003). The social play continuum. In *Early years play and learning* (pp. 48–62). Routledge. https://doi.org/10.4324/9780203465257_chapter_2

Cadieux, J., Chasteen, A. L., & Packer, D. J., PhD. (2019). Intergenerational contact predicts attitudes toward older adults through inclusion of the outgroup in the self. *The Journals of Gerontology: Series B*, *74*(4), 575–584. https://doi.org/10.1093/geronb/gbx176

Chang, W. L., Šabanovic, S., & Huber, L. (2013). Use of seal-like robot PARO in sensory group therapy for older adults with dementia. In *2013 8th ACM/IEEE International Conference on Human-Robot Interaction (HRI)* (pp. 101–102). IEEE. https://doi.org/10.1109/hri.2013.6483521

Claessens, N. (2013). Nursing home residents' media use from a life course perspective. *Northern Lights: Film & Media Studies Yearbook*, *11*(1), 35–50. https://doi.org/10.1386/nl.11.1.35_1

Cohen-Mansfield, J., & Werner, P. (1998). The effects of an enhanced environment on nursing home residents who pace. *The Gerontologist*, *38*(2), 199–208. https://doi.org/10.1093/geront/38.2.199

Dadlani, P., Sinitsyn, A., Fontijn, W., & Markopoulos, P. (2010). Aurama: Caregiver awareness for living independently with an augmented picture frame display. *Ai & Society*, *25*(2), 233–245. https://doi.org/10.1007/s00146-009-0253-y

Davis, K., Owusu, E. B., Marcenaro, L., Feijs, L., Regazzoni, C., & Hu, J. (2017). Effects of ambient lighting displays on peripheral activity awareness. *IEEE Access*, *5*, 9318–9335. https://doi.org/10.1109/access.2017.2703866

Descheneaux, C., & Pigot, H. (2009). Interactive calendar to help maintain social interactions for elderly people and people with mild cognitive impairments. In *International Conference on Smart Homes and Health Telematics* (pp. 117–124). Springer. https://doi.org/10.1007/978-3-642-02868-7_15

Feng, Y., van Reijmersdal, R., Yu, S., Hu, J., Rauterberg, M., & Barakova, E. (2017). Using observational engagement assessment method VC-IOE for evaluating an interactive table designed for seniors with dementia. In *International Conference on Smart Health* (pp. 26–37). Springer. https://doi.org/10.1007/978-3-319-67964-8_3

Fischer, P. T., Kuliga, S., Eisenberg, M., & Amin, I. (2018). Space is part of the product: Using attrakdiff to identify spatial impact on user experience with media facades. In *Proceedings of the 7th ACM International Symposium on Pervasive Displays* (pp. 1–8). ACM Press. https://doi.org/10.1145/3205873.3205875

Frederiks, A. D., Octavia, J. R., Vandevelde, C., & Saldien, J. (2019). Towards participatory design of social robots. In *IFIP Conference on Human-Computer Interaction* (pp. 527–535). Springer.

Gächter, S., Starmer, C., & Tufano, F. (2015). Measuring the closeness of relationships: A comprehensive evaluation of the'Inclusion of the other in the self'scale. *PloS One*, *10*(6), e0129478. https://doi.org/10.1371/journal.pone.0129478

Gaver, W., Boucher, A., Bowers, J., Blythe, M., Jarvis, N., Cameron, D., … Wright, P. (2011). The photostroller: Supporting diverse nursing home residents in engaging with the world. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 1757–1766). ACM Press. https://doi.org/10.1145/1978942.1979198

Gerling, K. M., Schild, J., & Masuch, M. (2010). Exergame design for elderly users: The case study of SilverBalance. In *Proceedings of the 7th International Conference on Advances in Computer Entertainment Technology* (pp. 66–69). ACM Press. https://doi.org/10.1145/1971630.1971650

Gillsjö, C., Schwartz-Barcott, D., & Von Post, I. (2011). Home: The place the older adult can not imagine living without. *BMC Geriatrics*, *11*(1), 1–10. https://doi.org/10.1186/1471-2318-11-10

Good, A., Omisade, O., Ancient, C., & Andrikopoulou, E. (2019). The use of interactive tables in promoting wellbeing in specific user groups. In *International Conference on Human-Computer Interaction* (pp. 506–519). Springer. https://doi.org/10.1007/978-3-030-22015-0_39

Gottesman, L. E., & Bourestom, N. C. (1974). Why nursing homes do what they do. *Gerontologist*, *14*(6), 501–506. https://doi.org/10.1093/geront/14.6.501

Hutto, C., & Bell, C. (2014). Social media gerontology: Understanding social media usage among a unique and expanding community of users. In *System sciences (HICSS), 47th Hawaii international conference, 2014*. IEEE. https://doi.org/10.1109/hicss.2014.223

Ice, G. H. (2002). Daily life in a nursing home: Has it changed in 25 years? *Journal of Aging Studies*, *16*(4), 345–359. https://doi.org/10.1016/S0890-4065(02)00069-5

Jansen, M., & Bekker, T. (2009). Swinxsbee: A shared interactive play object to stimulate children's social play behaviour and physical exercise. In *International Conference on Intelligent Technologies for Interactive Entertainment* (pp. 90–101). Springer. https://doi.org/10.1007/978-3-642-02315-6_9

Judge, K. S., Camp, C. J., & Orsulic-Jeras, S. (2000). Use of Montessori-based activities for clients with dementia in adult day care: Effects on engagement. *American Journal of Alzheimer's Disease*, *15*(1), 42–46. https://doi.org/10.1177/153331750001500105

Kang, K., Hengeveld, B., Hu, J., Zhang, S., & Hummels, C. (2019). R2S: A public augmented printed media system to promote care home residents' social interaction. In *Proceedings of the 21st International Conference on Human-Computer Interaction with Mobile Devices and Services* (pp. 1–7). ACM Press.

Kang, K., Hu, J., Hengeveld, B., & Hummels, C. (2018). Designing an augmented print media system to promote social interaction in nursing homes: A preliminary study. In *Proceedings of the Sixth International Symposium of Chinese CHI* (pp. 76–83). ACM Press. https://doi.org/10.1145/3202667.3202678

Kang, K., Hu, J., Hengeveld, B., & Hummels, C. (2019). R2S: Designing a public augmented printed media system to promote care home residents' social interaction. *Design and Semantics of Form and Movement*, 159. Wellington: Northumbria University. https://doi.org/10.21428/5395bc37.394ef63b

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. https://doi.org/10.3233/ais-180504

Kayser-Jones, J., Schell, E., Lyons, W., Kris, A. E., Chan, J., & Beard, R. L. (2003). Factors that influence end-of-life care in nursing homes: The physical environment, inadequate staffing, and lack of supervision. *The Gerontologist*, *43*(suppl_2), 76–84. https://doi.org/10.1093/geront/43.suppl_2.76

Leone, E., Piano, J., Deudon, A., Alain, B., Wargnier, A. M., Balard, P., Soriano, D., Malléa, P., Robert, P., & Dechamps, A. (2012). "What are you interested in?"—A survey on 601 nursing homes residents activities interests. *Advances in Aging Research*, *1*(2), 13–21. https://doi.org/10.4236/aar.2012.12002

Lin, C. X., Lee, C., Lally, D., & Coughlin, J. F. (2018). Impact of virtual reality (VR) experience on older adults' well-being. In *International Conference on Human Aspects of IT for the Aged Population* (pp. 89–100). Springer. https://doi.org/10.1007/978-3-319-92037-5_8

Mansbach, W. E., Mace, R. A., Clark, K. M., & Firth, I. M. (2017). Meaningful activity for long-term care residents with dementia: A comparison of activities and raters. *The Gerontologist*, *57*(3), 461–468. https://doi.org/10.1093/geront/gnv694

Memarovic, N., Langheinrich, M., Alt, F., Elhart, I., Hosio, S., & Rubegni, E. (2012). Using public displays to stimulate passive engagement, active engagement, and discovery in public spaces. In *Proceedings of the 4th Media Architecture Biennale Conference: Participation* (pp. 55–64). ACM Press. https://doi.org/10.1145/2421076.2421086

Mondaca, M., Josephsson, S., Katz, A., & Rosenberg, L. (2018). Influencing everyday activities in a nursing home setting: A call for ethical and responsive engagement. *Nursing Inquiry*, *25*(2), e12217. https://doi.org/10.1111/nin.12217

Moyle, W., Jones, C., Dwan, T., & Petrovich, T. (2018). Effectiveness of a virtual reality forest on people with dementia: A mixed methods pilot study. *The Gerontologist*, *58*(3), 478–487. https://doi.org/10.1093/geront/gnw270

Nazzi, E., & Sokoler, T. (2015). TwitterIDo: What if my shopping bag could tell my friends i'm out shopping. In *International Conference on Human Aspects of IT for the Aged Population* (pp. 512–523). Springer. https://doi.org/10.1007/978-3-319-20913-5_47

Ouden, M., Bleijlevens, M. H., Meijers, J. M., Zwakhalen, S. M., Braun, S. M., Tan, F. E., & Hamers, J. P. (2015). Daily (in) activities of nursing home residents in their wards: An observation study. *Journal of the American Medical Directors Association*, *16*(11), 963–968. https://doi.org/10.1016/j.jamda.2015.05.016

Pham, T. P., & Theng, Y. L. (2012). Game controllers for older adults: Experimental study on gameplay experiences and preferences. In *Proceedings of the International Conference on the Foundations of Digital Games* (pp. 284–285). ACM Press. https://doi.org/10.1145/2282338.2282401

Prante, T., Röcker, C., Streitz, N., Stenzel, R., Magerkurth, C., Van Alphen, D., & Plewe, D. (2003). Hello. wall–beyond ambient displays. In *Adjunct proceedings of ubicomp* (Vol. 2003, pp. 277–278). Springer.

Roberts, T., & Bowers, B. (2015). How nursing home residents develop relationships with peers and staff: A grounded theory study. *International Journal of Nursing Studies*, *52*(1), 57–67. https://doi.org/10.1016/j.ijnurstu.2014.07.008

Šabanović, S., Bennett, C. C., Chang, W. L., & Huber, L. (2013). PARO robot affects diverse interaction modalities in group sensory therapy for older adults with dementia. In *2013 IEEE 13th international conference on rehabilitation robotics (ICORR)* (pp. 1–6). IEEE. https://doi.org/10.1109/icorr.2013.6650427

Sedgwick, P., & Greenwood, N. (2015). Understanding the Hawthorne effect. *BMJ*, *2015*(351). https://doi.org/10.1136/bmj.h4672

Simard, J., & Volicer, L. (2020). Loneliness and isolation in long-term care and the COVID-19 pandemic. *Journal of the American Medical Directors Association*, *21*(7), 966–967. https://doi.org/10.1016/j.jamda.2020.05.006

Smallfield, S., Clem, K., & Myers, A. (2013). Occupational therapy interventions to improve the reading ability of older adults with low vision: A systematic review. *American Journal of Occupational Therapy*, *67*(3), 288–295. https://doi.org/10.5014/ajot.2019.038380

Stevenson, J. G., Beck, C., Heacock, P., Mercer, S. O., O'Sullivan, P. S., Hoskins, J. A., … Schnelle, J. F. (2000). A conceptual framework for achieving high-quality care in nursing homes. *Journal for Healthcare Quality*, *22*(4), 31–36. https://doi.org/10.1111/j.1945-1474.2000.tb00137.x

Street, D., & Burge, S. W. (2012). Residential context, social relationships, and subjective well-being in assisted living. *Research on Aging*, *34*(3), 365–394. https://doi.org/10.1177/0164027511423928

Streitz, N. A. (2003, October). Hello. wall–beyond ambient displays. In *Video Track and Adjunct Proceedings of the Fifth International Conference on Ubiquitous Computing (UBICOMP'03)*.

Teo, A. R., Choi, H., Andrea, S. B., Valenstein, M., Newsom, J. T., Dobscha, S. K., & Zivin, K. (2015). Does mode of contact with different types of social relationships predict depression in older adults? Evidence from a nationally representative survey. *Journal of the American Geriatrics Society*, *63*(10), 2014–2022. https://doi.org/10.1111/jgs.13667

Tong, S., & Walther, J. B. (2011). Relational maintenance and CMC. *Computer-mediated Communication in Personal Relationships*, *53*, 98–118. Peter Lang Inc.

Victor, C. R. (2012). Loneliness in care homes: A neglected area of research? *Aging Health*, *8*(6), 637–646. https://doi.org/10.2217/ahe.12.65

Visser, T., Vastenburg, M. H., & Keyson, D. V. (2011). Designing to support social connectedness: The case of SnowGlobe. *International Journal of Design*, *5*(3), 129–142.

Vutborg, R., Kjeldskov, J., Pedell, S., & Vetere, F. (2010). Family storytelling for grandparents and grandchildren living apart. In *Proceedings of the 6th Nordic conference on human-computer interaction: Extending boundaries* (pp. 531–540). ACM Press.https://doi.org/10.1145/1868914.1868974

Welsh, E. (2002). Dealing with data: Using NVivo in the qualitative data analysis process. *Forum Qualitative sozialforschung/Forum: Qualitative Social Research*, *3*(2), Art. 26. http://nbn-resolving.de/urn:nbn:de:0114-fqs0202260

Woodward, A. T., Freddolino, P. P., Blaschke-Thompson, C. M., Wishart, D. J., Bakk, L., Kobayashi, R., & Tupper, C. (2011). Technology and aging project: Training outcomes and efficacy from a randomized field trial. *Ageing International*, *36*(1), 46–65. https://doi.org/10.1007/s12126-010-9074-z

Wouters, N., Downs, J., Harrop, M., Cox, T., Oliveira, E., Webber, S., … Vande Moere, A. (2016). Uncovering the honeypot effect: How audiences engage with public interactive systems. In *Proceedings of the 2016 ACM Conference on Designing Interactive Systems* (pp. 5–16). ACM Press. https://doi.org/10.1145/2901790.2901796

Yuan, S., Hussain, S. A., Hales, K. D., & Cotten, S. R. (2016). What do they like? Communication preferences and patterns of older adults in the United States: The role of technology. *Educational Gerontology*, *42*(3), 163–174. https://doi.org/10.1080/03601277.2015.1083392

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