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Enhancing social interaction in nursing homes through public tabletop displays: A field study of R2S

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ABSTRACT

The prevalence of social isolation among nursing home residents highlights the need for innovative solutions to enhance their social interactions and wellbeing. Despite extensive efforts over recent decades to develop in-room systems or public applications under caregivers' supervision, there remains a gap in designing public social technologies that can be integrated into residents' daily lives. Furthermore, the challenges associated with low adoption and the complexities of evaluating such technologies in public care settings have limited our understanding of their impact on residents' social activities and experiences. To address this, our study introduces R2S, a tabletop display system designed to encourage older adults to view, share, and discuss news articles collaboratively in public care environments. A 6-week field trial was conducted in a Dutch care home to investigate the influence on residents' daily social activities, R2S's utilization, and residents' perceived user experiences and social emotions. The results reveal that R2S can generally promote daily social interactions among residents, even altering their long-established social habits. Five usage patterns of social technologies within public care environments were identified to provide insights into designing systems in comparable contexts. The participants reported a highly positive user experience with the system. Although their affective social benefits were not significant, they substantially outweighed the affective costs. These findings not only deepen the understanding of how technology can enhance social interaction in public care settings but also provide insights to inform the design and implementation of related technologies in the future.

Introduction

As the global population ages, an increasing number of older people are opting for institutional care. Numerous studies indicate that active peer interactions are one of the key indicators of quality of life and well-being for care home residents.[1] To promote such interactions, various public areas have been set with a focus on residents' social well-being. However, despite the notable advancements in care environments and services, issues like boredom, loneliness, and a sense of helplessness have persisted as common problems.[2] Researchers have proposed that residents should engage more frequently in public spaces,[3] yet numerous surveys have shown that a significant portion of residents continue to spend substantial time inactively in their own rooms,[4,5,6] which calls for effective interventions to maintain their social vitality.

Organizing scheduled activities within public nursing environments has been recognized as a mainstream social intervention.[7] The programs often revolve around various themes, such as reminiscence and life review, creative expression, sensory stimulation, pet and animal therapy, and intergenerational interaction.[8] Although the benefits of social activities are supported by a body of research, their effects are often limited by staffing and resource constraints, scheduling and timing, and diverse resident preferences.[9] Furthermore, most programs account for only a small fraction of residents' daily routines.[6] Research has shown that residents tend to engage in less structured activities, often unplanned and initiated by themselves.[10] However, the issue of how to support residents when not in structured programs is often overlooked by existing research.[11] Therefore, it is essential to explore solutions to enhance and maintain residents' social interaction throughout the day.[12]

In recent decades, a growing body of research has begun to explore how technology can support nursing home residents' social interaction. There has been a specific focus on utilizing technologies in structured social activities. For example, devices like smartphones

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0197-4572/$ – see front matter © 2024 Elsevier Inc. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

and tablets have become widely adopted by caregivers to present media content.[9] Emerging technologies, such as Augmented Reality (AR), Virtual Reality (VR), and body tracking, are also being increasingly applied to enhance residents' engagement in structured activities.[13,14] However, the technologies applied to support residents' unplanned daily activities were much less explored. The major efforts in this domain are dedicated to the design and development of social robots and interactive public display systems.[15,16,17] Although some researchers have preliminarily reported positive impacts of such technologies via field testing,[18] up until now, little is known about how residents react to such technologies in their daily lives and the roles of these technologies in the social dynamics of care environments.

This paper introduces the design of a public tabletop display system named 'Reading-to-Sharing' (R2S). It is a flexible platform aiming to enhance daily social activities among nursing home residents through augmenting their newspaper reading experience. A field study of R2S was conducted to evaluate its social impact and user experience. This study concentrates on residents' interactions with R2S and its incorporation into their social routines, aiming to provide guidance on the design and application of technology-based interventions that encourage and facilitate daily social interactions within nursing homes.

Reading-to-Sharing (R2S)

Design rationale

Our prior study found that reading in the common spaces of nursing homes is a common daily activity for many residents. However, due to physiological decline, such activity has become increasingly difficult and less attractive. Besides, traditional print media products were mainly used by individuals, which was unlikely to create social opportunities, especially for older users. Hence, we hypothesized that digital augmentations may enhance the accessibility of print media and foster more social interactions. The concept development of R2S mainly involved a user study and two rounds of co-design. The user study aimed to understand residents' media habits, content preferences, and the related social scenarios and barriers. The co-design sessions focused on shaping and refining the concept.

Concept design

Fig. 1 illustrates an envisioned usage scenario of R2S. The system comprises a series of display units placed on the public tables of nursing homes. Each unit comprises three elements: IStamp, IStickers, and a display with the R2S application. This system serves as a versatile platform, enabling caregivers to transform any print media into interactive surfaces and providing residents with convenient access to their preferred digital information. The digital augmentation is expected to promote and facilitate communication among residents by overcoming physical and social barriers.

IStickers are a set of transparent stickers highlighted with colored edges (Fig. 2). In the physical world, IStickers appear identical, but each sticker carries a distinct digital code for recognition. To create interactive spots on print media, caregivers just simply to adhere IStickers near the content that might interest residents.

IStamp is designed to identify each ISticker and further interact with corresponding digital information. As shown in Fig. 3, the shape of IStamp takes inspiration from traditional stamps. It's ergonomically designed for seniors, allowing for easy handling without constant holding. Additionally, this metaphorical design naturally conveys its inherent connection with print media. The fundamental interaction of this system also draws inspiration from the familiar stamping motion commonly known to older adults. As depicted in Fig. 3, users simply need to "stamp" on each sticker to access associated digital content. As users gradually master the basic operations, they can explore more advanced interactions by rotating or pressing the handle, which enables in-depth control over media information. Given the technology acceptance and sensory degradation of older users, IStamp also provides both visual and auditory feedback to spark user interest and facilitate its operation (Fig. 4).

The R2S application features two modes: Edit Mode, primarily designed for caregivers, and View Mode, intended for residents (Fig. 5). In Edit Mode, caregivers can easily obtain the embedded code within each sticker through the "stamping" interaction. Then, they

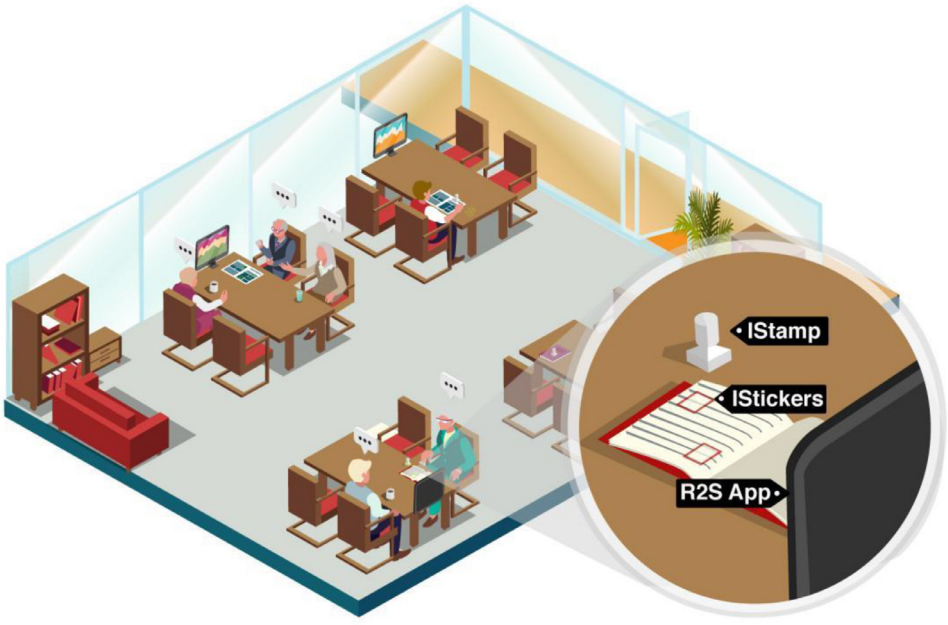


Fig. 1. The concept illustration of R2S.

Fig. 2. IStickers are designed to create interactive spots on paper surface.

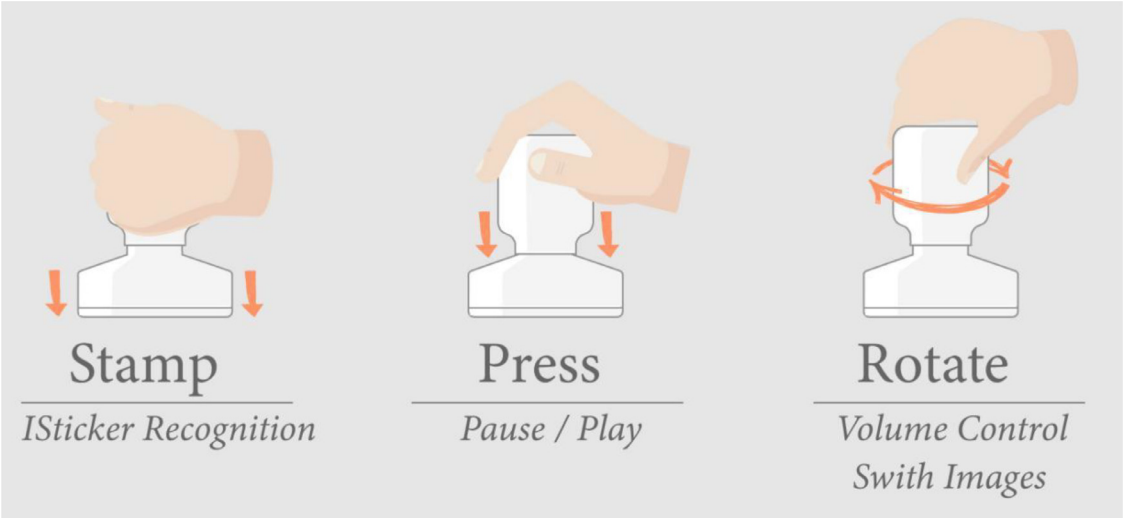


Fig. 3. The three ways to interact with IStamp.

Fig. 4. IStamp can provide visual and auditory feedback to users.

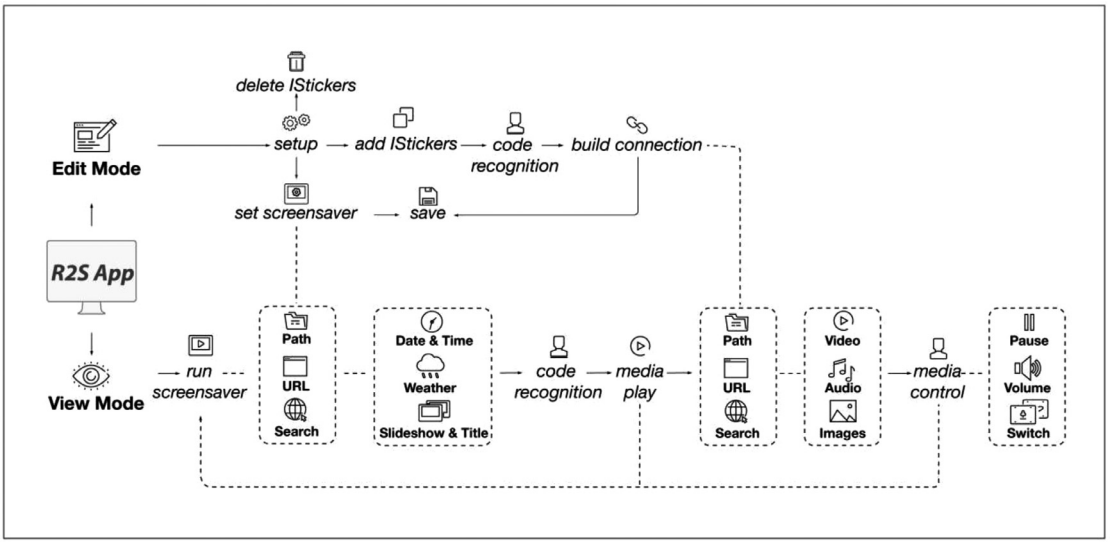


Fig. 5. The system architecture of R2S App.

can associate these stickers with specific digital content by inputting local paths or network links. They can also just enter some keywords to let the system perform an online search for the most relevant content.

When the application switches to View Mode, the system will automatically initiate a screensaver which is ready for residents to activate. The screensaver demonstrates the date, time, weather, and a slideshow of the edited content with necessary instructions (Fig. 6). Once residents "stamp" on the edited stickers, the display will directly show the associated media files. They can either watch or further control them to facilitate communication with their peers.

Prototype implementation

To conduct real-world testing, we developed a prototype of R2S with complete functionality. IStickers were made of transparent foils highlighted with magenta glossy edges. Each sticker was embedded with an NFC tag that can be identified by the NFC reader mounted at the bottom of IStamp. To lower the technological barrier, IStamp was constructed with common materials used in vintage devices, such as aluminum, wood, and acrylonitrile butadiene styrene (Fig. 7). The sound feedback comes from the embedded speaker in the handle and the light feedback is achieved through the LED lights above the transparent bottom cover. Given the lack of assistance from designers or caregivers during the field trial, we prepared a digital tutorial and a printed manual to guide their use. As illustrated in Fig. 7, the tutorial demonstrates the primary interaction of stamping on the stickers and cycles through as part of the screensaver sequence. The manual was positioned near the display for easier access.

Additionally, the software system was implemented by developing an application on the Android platform. This allows caregivers to easily edit content on their phones and then synchronize it with the

Fig. 6. The home page in View Mode.

Fig. 7. The functional prototype of R2S with digital and printed instructions.

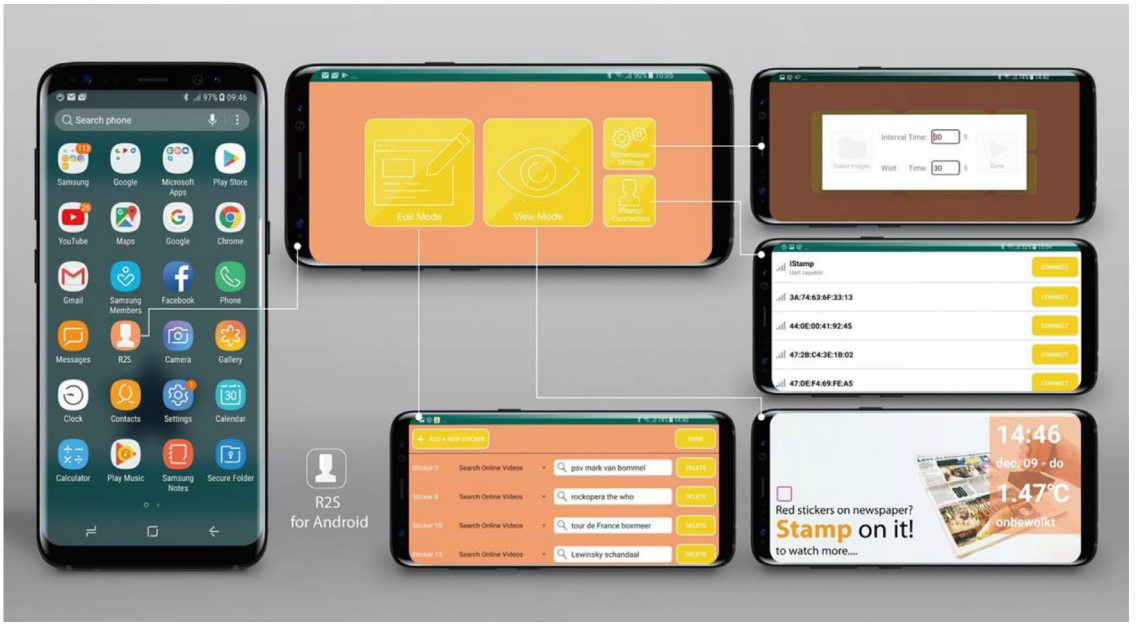


Fig. 8. The functional R2S app for Android systems.

public display. As shown in Fig. 8, the R2S application offers various options for caregivers to edit content and configure the slideshow. A single device equipped with the application can be paired with one stamp via Bluetooth.

Field study

Objectives

To evaluate the influence of R2S on the social interaction and well-being of nursing home residents, we conducted a field study in a real-world setting. The primary objectives of this trial were to examine:

1. To what degree and how would R2S influence residents' daily social activities?
2. To what degree and how would residents incorporate R2S into their everyday routines?
3. What are residents' perceptions of their user experience and the social emotions derived from using R2S?

Setting

The nursing home was situated in a middle-income community of Eindhoven, the Netherlands. As shown in Fig. 9, it comprised three residential buildings with a variety of outdoor and indoor supporting facilities, including a central meeting room (CM for short), a restaurant, a garden, and a chapel. These common areas and residential buildings were interconnected via corridors, providing residents with easy access to all facilities.

We selected CM as the deployment location primarily because it served as the central hub for residents' self-initiated or scheduled

Fig. 9. Architectural layout of the nursing home.

Fig. 10. CM serves as the central hub for residents' social activities.

social activities (Fig. 10). CM had multiple tables and chairs, primarily serving as a café to provide drinks and snacks. To promote residents' social interactions in communal spaces, free coffee is provided daily from 2:00 PM to 4:00 PM. Additionally, structured activities were usually hosted in CM at least once a week. Residents could enter CM through either the front or back entrance from different residential buildings and facilities.

To preliminarily investigate the activities and behavioral patterns of residents in CM, we conducted a week-long structured observation. As shown in Fig. 11, all the tables in CM were labeled with alphanumeric codes to facilitate observation. Detailed methods for this observation are described in the subsequent data collection section. We found that most residents' activities in CM were highly regular. Besides, the tables in CM have been gradually assigned different roles and functions due to the residents' long-term usage habits. They preferred to sit at the tables corresponding to their social role and needs in CM, indicating that different categories of tables represent different social contexts. Based on our observation, three categories of tables were identified as follows:

(i) *Group Reserved Table (T1, T3)*
A "group reserved table" refers to a table that is frequently occupied and implicitly reserved for a specific social group. Observational records indicate that two social groups used T1 and T3 daily for their social routines. Although designed to seat 6 people, these

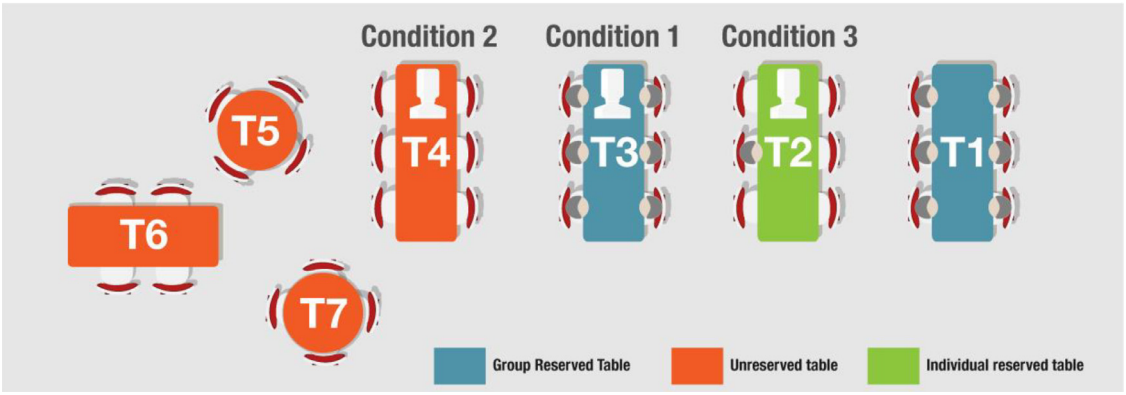


Fig. 11. We set up three conditions by deploying R2S at different types of tables.

tables commonly accommodated nearly 10 residents who preferred to bring additional chairs rather than sit at other available tables.

(ii) *Unreserved table (T4, T5, T6, T7)*
Tables of this category do not have fixed users. Field journals suggest they were primarily utilized by residents who infrequently visit CM. These tables served individuals engaging in activities like reading, drinking coffee, or seeking social interactions, as well as friends and family members visiting by appointment.

(iii) *Individual reserved table (T2)*
This category includes tables mainly used by individuals not affiliated with any social group. Field notes revealed that a woman regularly occupied Table 2, typically sitting alone or quietly observing with another woman who appeared occasionally. Consequently, other residents generally avoided using T2 when visiting CM.

To investigate the impact of R2S on residents' activities in different social contexts, we decided to sequentially deploy R2S at various types of tables. As shown in Fig. 11, we set Condition 1 as R2S installed at the group-reserved table (T3), Condition 2 as R2S at the unreserved table (T4), and Condition 3 as R2S at the individual-reserved table (T2).

Study design

We employed a quasi-experimental design incorporating descriptive research methods that combined both quantitative and qualitative data.[19] As shown in Fig. 12, the field study consisted of four phases. Given that most residents adhered to weekly schedules for their activities, each module of the field study was conducted over a one-week period.

In Phase 1, we employed structured observations from 2 PM to 4 PM to gather residents' behavioral data before deployment. The findings could not only help identify residents' current daily activity patterns but also serve as a baseline for the comparison with the deployment phase.

In Phase 2, one unit of R2S was installed in CM and demonstrated daily from 2 PM to 4 PM. It aimed to familiarize residents with R2S and the upcoming deployment while testing the usability of the system. Under the guidance of two research assistants, residents were invited to experience R2S and provide their initial feedback through brief interviews.

Phase 3 was divided into three stages, each lasting one week. During each stage, a single unit of R2S was placed at a different table in CM as one condition. During these periods, R2S was set up and activated by 1:30 PM and remained in operation until 4:30 PM daily. Observational method used in this Phase were consistent with that in Phase 1.

In Phase 4, the two research assistants visited CM daily between 1:30 PM and 4:30 PM to collect residents' subjective data via semi-structured interviews and questionnaires. Participant recruitment was primarily guided by observation logs, but other factors, such as their availability and willingness to participate, also influenced the selection process. For residents who did not engage with R2S during the deployment period, we conducted random recruitment to ensure a diverse range of participants. Additionally, R2S remained in CM throughout Phase 4 to assist residents in recalling their memories.

Data collection

Guided by the objectives, the data collected in this study included residents' behavioral data, usage data of R2S, and residents' subjective data. The data collection and management methods were jointly developed with the nursing staff and approved by the management committee of the nursing home.

To gather residents' behavioral data, we employed a method that combined video and manual recording. As shown in Fig. 13, a web camera was installed at Entrance B, primarily recording the area from T1 to T7. To protect residents' privacy, the captured footage was processed to obscure their faces before saving. Additionally, a notice was posted within the coverage area to inform residents that they are in a monitored zone. Manual recording was performed by an on-site experimenter sitting at T13. The recorded information primarily included the appearance of typical residents, and any unusual behaviors or events observed within the coverage area.

Fig. 12. The procedure of the field study.

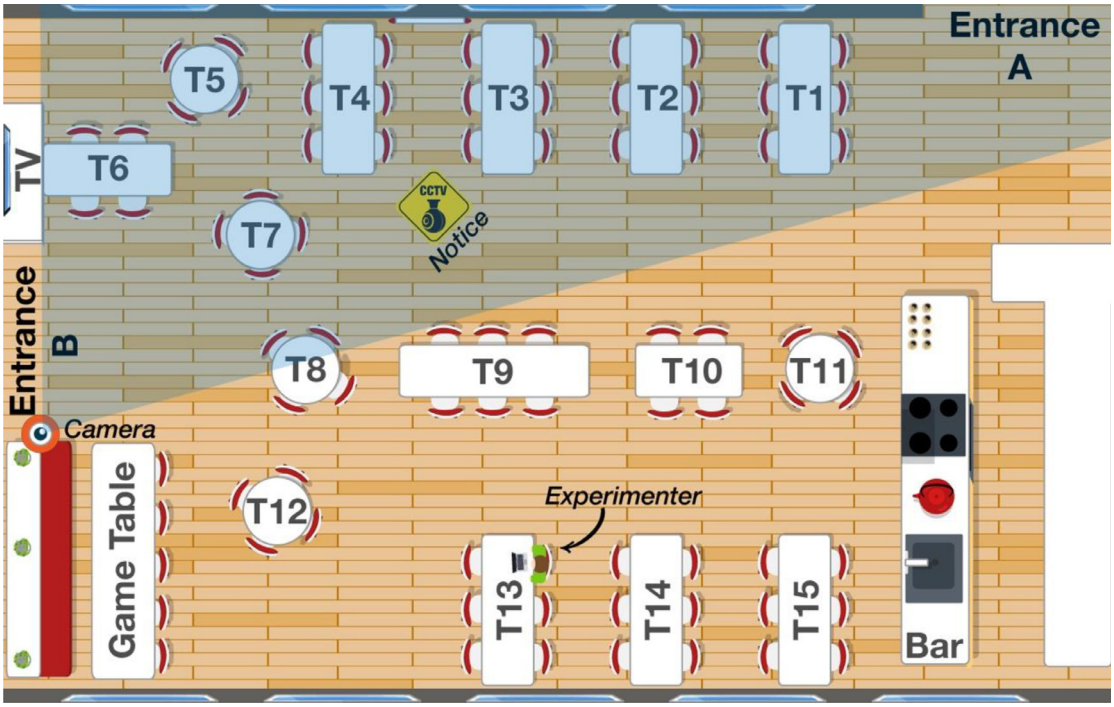
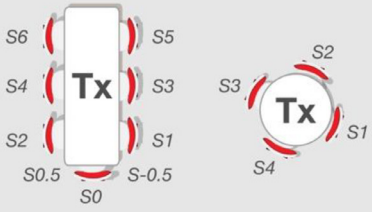


Fig. 13. The method to gather residents' behavioral data.

To ensure the data collected was ready for detailed analysis in the next phase, video recordings were transcribed into a spreadsheet. We applied scan sampling to systematically document residents' behavior within the observation zone at one-minute intervals. Fig. 14 illustrates an example of the datasheet, which includes entries for the subjects' identity (anonymized), gender, time, behavior, location, posture, and additional notes. Identification was primarily based on observable characteristics like appearance, gait, and attire due to the anonymization of video records. Frequent subjects were given pseudonyms to facilitate easier tracking. Behaviors were categorized into two types: events and states. An event refers to transient behavioral patterns such as entering or exiting the observation zone, marked precisely by their occurrence time. A state describes prolonged behaviors, like conversing or fixating on someone or something, recorded by their starting and ending times. Rather than detailing every nuance of subjects' behaviors, we broadly classified their states into social or unsocial. The social state encompasses minimal to extensive social interactions among subjects in proximity. The unsocial one is characterized by subjects being solitary or positioned distantly from their peers without engaging in communication. As shown in Fig. 14, the locations and postures of subjects were documented using coded labels to facilitate transcription and analysis. The observation area was segmented into subareas

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	

Fig. 14. A sample of the spreadsheet to analyze the video records.

aligned with table arrangements. For subjects seated at a table, their specific seating positions were coded for subsequent tracking.

The usage data was collected via system logs exported by the R2S app, which documented direct interactions with the interface such as stamping, pausing, and volume adjustments, as well as auxiliary data like date, time, RFID codes, and link of played videos.

Residents' subjective data were gathered through post-interviews and questionnaires. The participants were recruited under the guidance of observation logs. They were classified into three distinct groups according to their engagement in the study. Group 1 participants were introduced to and utilized R2S during Phase 3. Their usage of R2S and its consequential impact were explored through semi-structured interviews. To delve deeper into residents' social emotions, structured inquiries adapted from the ABCCT (Affective Benefits and Costs of Communication Technologies) questionnaire were employed.[20] Affective benefits refer to the positive emotional outcomes or enhancements that users experience from using a particular technology. Affective costs, on the other hand, refer to the negative emotional outcomes or drawbacks associated with using a technology. The questionnaire covered seven scales: four relating to affective benefits and three to affective costs, allowing for a broad exploration of the emotional and social impacts of the communication technologies used. Group 2, while not present for the introductory session, used R2S afterward. The inquiry set for Group 2 encompassed all questions for Group 1, with additional queries regarding their discovery and learning process related to R2S utilization. Group 3 attended the introduction but did not use R2S during the deployment phases. They were interviewed about their reasons for non-use and potential improvements. Following the interviews, Groups 1 and 2 participants completed the UEQ-S (User Experience Questionnaire - Short Version) to assess their overall user experience.[21,22] Given the prevalent reading or writing challenges among many participants, consent was acquired verbally before each session, and interviews were recorded with their explicit approval.

Data analysis

Upon finalizing the data transcription into the spreadsheet, we assessed R2S's impact on residents' behavior by calculating their attendance and time spent at different tables. The video files were subsequently uploaded into Nvivo for further examination. Records were annotated based on details from the field journals and the spreadsheet descriptions. These annotations then underwent qualitative analysis via thematic techniques.[23] The system logs were also converted into a spreadsheet. The spreadsheet cataloged the key information of each operation, including the start time and end time, the operation type, and the headline of the displayed content. Upon completion, the total operational time could be calculated. The interview records were transcribed and then imported into NVivo. Participant responses, especially those describing usage patterns and habits, were manually coded and categorized using thematic analysis techniques. Their answers to the ABCCT questions were also coded and categorized based on the seven scales mentioned above. Additionally, responses to the UEQ-S questionnaire were analyzed using its official analysis tool.[21] This tool facilitates the calculation of mean scores for the two meta-dimensions of user experience—pragmatic and hedonic quality—and compares these scores against a benchmark dataset. This comparison aids in contextualizing the user experience findings within a broader framework, providing a clear perspective on the impacts of the technology used.

Results

Influence on residents' social activities

The influence of R2S on residents' daily activities could be directly reflected through the changes in the number of residents who came to different tables (Fig. 15) and the duration of their stay at the tables (Figs. 16 and 17). Although the study recorded nearly half of the central meeting room (CM), we focused our analysis on Tables T2, T3,

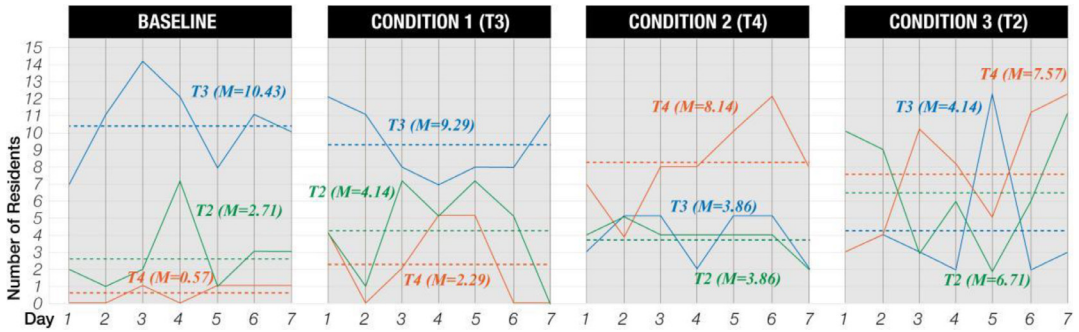


Fig. 15. Total number of residents at each table recorded daily during the baseline and the three conditions.

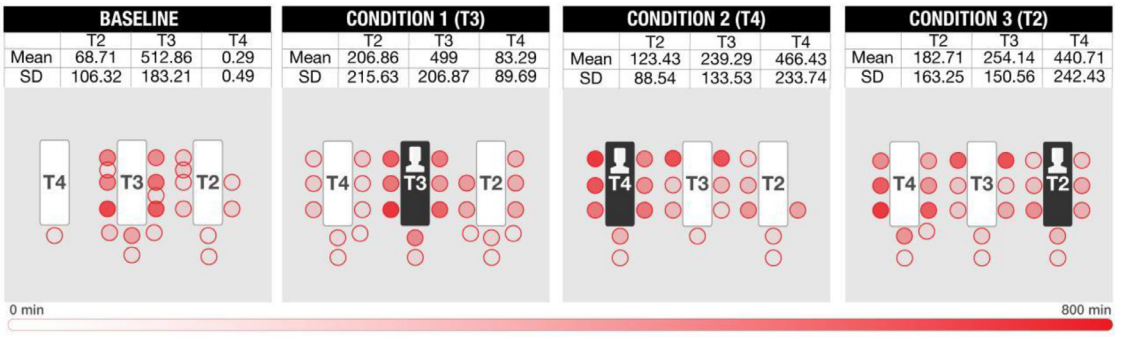


Fig. 16. Total minutes of social state recorded daily at each table during the baseline and three conditions.

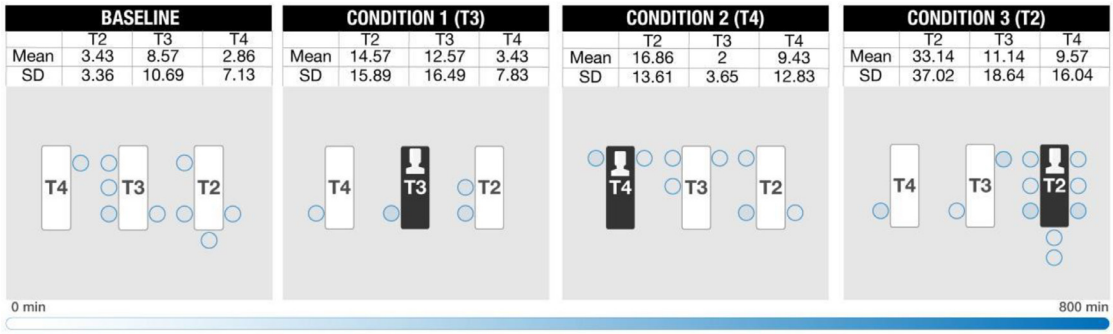


Fig. 17. Total minutes of unsocial state recorded daily at each table during the baseline and three conditions.

and T4 because they were directly related to our study and because very little change was observed at other tables.

(i) *Condition 1: Deployment at T3*

Following the installation of R2S at T3, we found T3 continued to be a favored spot for the social group. Since many group members had participated in the introductory week, the field journal indicated that T3 maintained their regular gatherings, integrating R2S into their activities without disruption. Additionally, R2S proved to be a point of interest for many passersby who would pause and watch the group using R2S. Occasionally, the members of the Table 3 group would invite and assist these onlookers to participate when seating was available. However, since T3 mostly reached its full capacity, these residents often choose nearby tables to observe and wait for an opportunity to join. This accounts for the noticeable rise in both the occupancy and the length of time spent at T2 and T4 in Condition 1.

(ii)*Condition 2: Deployment at T4*

After R2S was moved to T4, we observed a noticeable rise in the number of residents congregating at T4, alongside a significantly longer duration of social interaction compared to the previous weeks. Meanwhile, the number of residents frequenting T3 saw a considerable decline. According to the video records and field journal, this shift occurred as some key members of the T3 group followed R2S to T4. This situation was surprising because it is uncommon for established group members to alter their long-standing seating habits. Additionally, the field journal indicated that T4 attracted new members, likely because it was perceived as more accessible than the “group reserved table.”

(iii) *Condition 3: Deployment at T2*

Overall, the deployment of R2S at T2 led to a peak in both the average number of residents visiting and the time spent at this table over the course of four weeks. There were minimal changes in the conditions at T3 and T4 relative to Condition 2. The journals and video evidence revealed that the social group at T4 did not move to T2 with R2S, possibly because T2 remained under the occupation of the woman who had "claimed" it. Although the woman rarely used R2S on her own, we observed many residents from T1 shifted to T2 to use R2S with her. This could explain the significant increase in the number of residents at T2 in the first two days of Condition 3. As these individuals gradually returned to T1, residents lacking stable social groups saw more opportunities to engage with R2S at T2, leading to increased instances of unsocial interaction times, which were the longest observed during this condition at T2.

Use of R2S

(i) *Usage time of IStamp*

Fig. 18 illustrates the total daily duration of iStamp usage across the three conditions. In Condition 1, IStamp was actively used by the social group at T3, with the mean usage time exceeding one hour per day. The field journal indicated that the group members

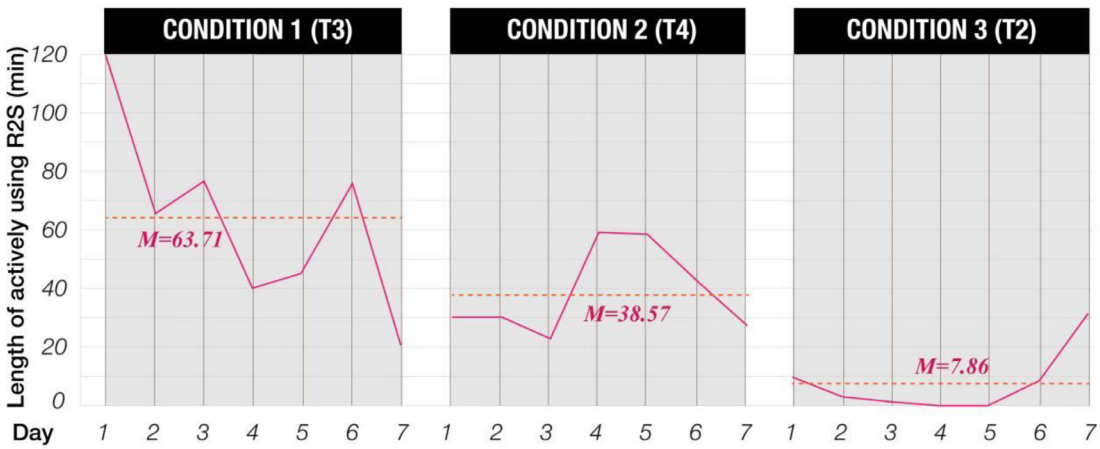


Fig. 18. Total minutes of IStamp usage recorded daily during the three conditions.

who joined the introduction activity could use R2S proficiently and assist other members. In Condition 2, R2S continued to be regularly used by the original social group at T4. Since most members had become familiar with R2S, the average usage time stabilized at more than half an hour. In Condition 3, despite higher attendance at T2, IStamp saw minimal active use. The field notes suggested that most residents preferred a more passive interaction with R2S, flipping through newspapers and watching slideshows. This might be because most of the residents observed in this condition did not participate in the introductory session, including the woman who occupied T2. The woman didn't use IStamp until the sixth day when another resident stopped by and taught her how to use it. Notably, the woman at T2, who initially did not participate in the introductory sessions, began using IStamp actively towards the end, significantly increasing its use and attracting more residents by the final day.

(ii)*Usage patterns*

In Phase 4, twenty-one residents were identified and invited to participate in the post-trial interviews, with seventeen agreeing to join. The participants were divided into three groups based on their involvement with R2S: six were in Group 1, having attended the introduction and subsequently used R2S; nine were in Group 2, who used R2S without attending the introduction; and two were in Group 3, attending the introduction but not using R2S thereafter. Through the interviews, five distinct usage patterns emerged:

Active use: Two participants, both from the introductory session, integrated R2S actively into their routines. They were part of the social group at T3 but switched to T4 during Condition 2. Apart from the seating preferences, R2S also impacted their established habits of reading newspapers. One woman remarked, "*I used to start with reading the articles. Now, I prefer to watch the video first if others join the table.*" Similarly, the other man stated, "*If something catches my eye, I'll use the stamp to watch the video. If it gives me all the information I need, I won't bother reading the articles.*"

Adaptive use: Two participants used R2S based on its availability and ease of access. One man had attended the introduction, while the other man learned to use R2S from others. They were very active users when R2S was available at T3, their usual spot, but did not engage with it under other conditions. Both of them agreed that R2S enriched their daily communication, but they would not seek to use it. Besides, they were very selective about the content to share. One remarked, "*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 engaged with R2S very frequently, but mainly in a passive way. Most of them belonged to stable social groups and were attracted by their peers' engagement with R2S. Nonetheless, either due to technological acceptance or personal character, they tended to let others lead in its use. A woman described, "*I watch when others use it. It's relaxing to watch and then have a laugh or chat about the videos occasionally.*"

Opportunistic use: Six participants engaged with R2S sporadically, seizing opportunities as they arose. Two of them had joined the introduction. One woman expressed a strong interest in R2S but complained that it was always occupied by social groups, leaving her with few opportunities to interact with it. One mentioned, "*There was one time when they weren't there, and then I finally had the chance to use it.*" In contrast, another woman stated that she only used it when there were people to share the experience with. The remaining four participants also used R2S under specific circumstances, such as being invited or when they happened to pass by.

Non-use: Two participants, despite attending the introduction, did not engage with R2S.

One man rarely visited CM due to his voluntary work outside the nursing home. Another woman preferred to sit at her usual table and read alone. "*I think many people here appreciate this. But I'm not the kind of person who easily tries new things.*" She also expressed concern that joining a social group to which she did not belong might lead to gossip. She stated, "*Everything you do here spreads around very quickly.*"

User experience

Interviews with Group 1 and Group 2 participants revealed that their overall user experience with R2S was very positive, particularly praising its practicality in enhancing newspaper readability in CM. "*For those who have difficulty reading, they can watch and listen to it!*" One man commented. Another man remarked, "*I appreciate how it provides more information, more depth. It covers topics I can see on TV and others I can't.*" Specifically, most of them expressed their fondness for R2S's simple design and friendly interface. In terms of functionality, they highlighted the importance of sensory compensation. One man said, "*I am slightly deaf, so I need to turn up the volume, but sometimes I had to lower it when other people joined.*" In addition, many participants appreciated the presentation of slideshows and real-time information. One man mentioned, "*We like the weather forecast. I know there are mobile apps, but many people don't use that.*" Moreover, the sociability of R2S was acknowledged by most participants. A man who used to read newspapers in his room remarked, "*Now I prefer to read the newspaper and watch the videos here, surrounded by other people, because then you hear people talking about it.*" A woman expressed similar feelings: "*I find it exciting to use the stamp with others, and I am curious about others' opinions.*" Regarding improvement suggestions, two participants wished more units could be installed because R2S was often occupied by other groups. Another participant hoped that more ways could be developed for viewers to influence the displayed information. "*The news is for everyone but mostly the person who has the stamp decides what is on the screen.*"

The UEQ-S questionnaire results, completed by fourteen out of fifteen participants from Groups 1 and 2, confirmed the positive user experience, with all mean values for the three attributes scoring above +0.8 (Fig. 19). The mean results for each item, as shown in Fig. 20, indicate that all metrics were positively rated. However, there is room for improvement in the pragmatic quality attributes, particularly in enhancing the efficiency of R2S in displaying users' desired content. Some participants expressed frustration over the time-consuming process of searching for stickers, which hindered their ability to access needed content. Fig. 21 shows a comparison between scale means and the UEQ benchmark, highlighting that while the overall attractiveness and hedonic quality of R2S are rated as excellent, the pragmatic quality scores in the "Above Average" category. This suggests that future improvements should focus on enhancing the efficiency and practicality of the system.

Affective social benefits and costs

Benefit 1: self-expressiveness

The questions evaluated if the social technology aids users in expressing their feelings and understanding others' emotions. All participants agreed that R2S facilitated their expression and understanding of others, particularly for secondary group members who typically played a more passive role in social activities and those who visited the public areas less often. "*I can get insights into others' interests because of this.*" One man mentioned. However, for dominant social group members, this benefit was less noticeable as they already possessed robust social skills.

Fig. 19. Mean scores of the UEQ-S for pragmatic quality, hedonic quality, and overall attractiveness.

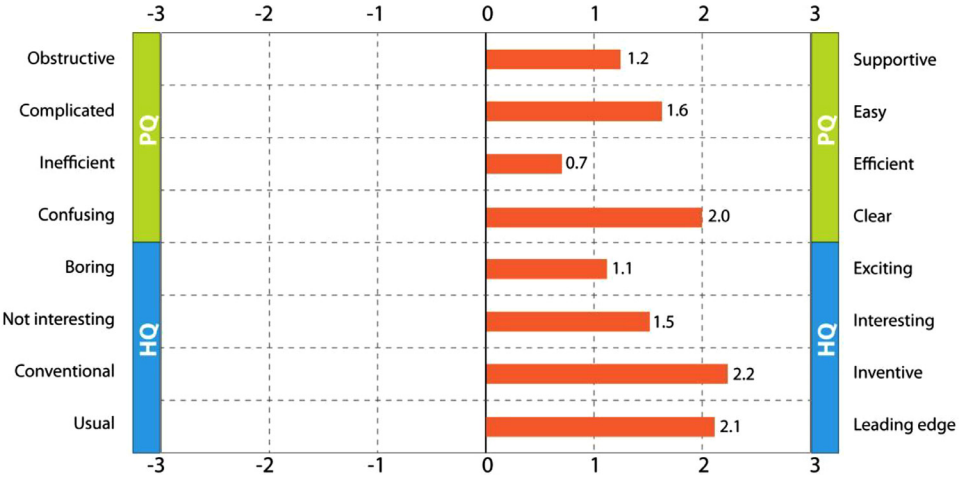


Fig. 20. Mean value per item in the UEQ-S.

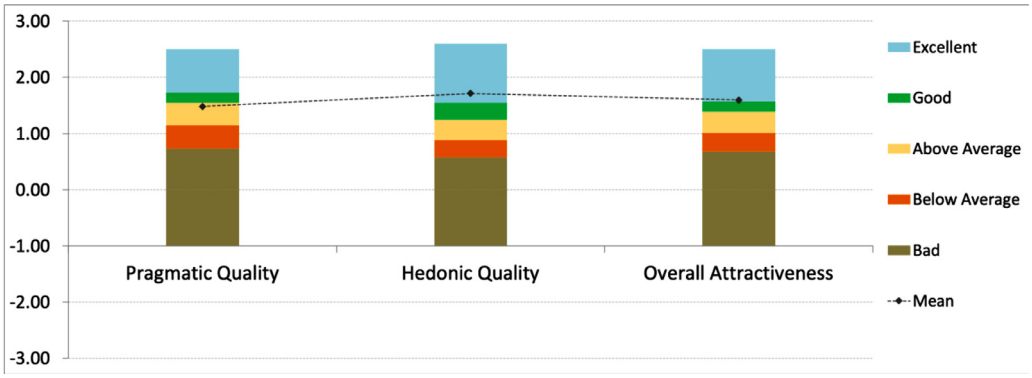


Fig. 21. Comparison of scale means with the UEQ benchmark.

Benefit 2: engagement and playfulness

This section assessed whether interactions through R2S were enjoyable and engaging. The general feedback was positive, although engagement levels varied by individual circumstances and familiarity with other users. Three participants explicitly expressed interest in using R2S, especially when engaging with others. Two participants enjoyed the experience when interacting with friends but were indifferent when joined by unfamiliar individuals. Additionally, one man noted that his enjoyment was influenced by both the people he was with and the content being displayed.

Benefit 3: presence-in-absence

This scale focused on whether R2S could foster feelings of closeness among users. Most participants did not feel significantly closer to others, particularly the key group members who felt they already had strong connections with others. One participant explained that the superficial nature of the displayed content often limited deeper emotional connections. Some participants reported feeling closer when using R2S, but only when interacting with their friends.

Benefit 4: opportunity for social support

This part aims to understand whether the social technology provides users with opportunities for social support. Two participants mentioned that they felt they could support others when using iStamp. "*I feel that I can bring each other closer,*" one of them said. Some participants felt supported by others when they were guided to use R2S. In most cases, they only felt supported when they saw content that resonated with them or their friends.

Cost 1: feeling obligated

This aspect of affective cost examines whether the social technology creates an unwanted obligation to communicate with others. None of the participants reported feeling obligated to use R2S. Those who joined others or used R2S passively indicated they felt attracted to the interaction rather than compelled. "*I was not forced to do anything. I decided that for myself,"* one participant explained. Participants who actively engaged with iStamp viewed the social interaction as a beneficial addition, not a necessity. "*I have never felt obligated. I just used it, and other people can use it if they want to,"* another participant stated. However, one individual recounted a less favorable experience: "*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.*"

Cost 2: unmet expectations

This aspect aims to explore situations where unmet expectations lead to negative emotions. Most participants reported that they rarely experienced such feelings. They attributed this to their low expectations when using R2S, given that it is common for people in this community not to engage deeply with each other. However, one participant noted that his disappointment arose particularly when topics of personal interest were ignored: "*Sometimes I find it upsetting when people don't want to talk about the topics."*

Cost 3: threat to privacy

These questions aim to assess concerns regarding the potential exposure of one's privacy through the use of R2S. No participants felt that their privacy was compromised by using R2S. This was largely because the device was located in a public setting and the content displayed typically involved general news, which was appropriate for communal viewing. One participant remarked, "*The news is for everyone, so I don't think privacy is relevant here.*" Additionally, many users valued the control they retained over what information was displayed: "*If I don't want people to see, then I just don't stamp on it.*" This feature helped alleviate potential privacy concerns.

Conclusions

Prior research has uncovered the need to design more engaging public facilities to promote residents' social interaction throughout the day. In this study, we introduce R2S, an interactive public tabletop display system designed specifically for nursing environments. It enables residents to view, share, and engage in discussions about news articles. A 6-week field study was conducted in the communal meeting area of a Dutch nursing home to assess the effectiveness of the R2S system.

The result indicated that although residents' reactions varied with conditions, R2S has been proven to have an overall positive influence on their social activities. We found that deploying the system on the tables "claimed" by groups was likely to reach a high degree of adoption. Although primarily utilized by existing group members, R2S could seamlessly blend into the residents' daily routines. Conversely, installing the system on "unclaimed" tables could foster a more inclusive social environment, offering greater opportunities for non-group members to engage. Moreover, it was encouraging to find that R2S was able to motivate residents to alter their longstanding social patterns and group dynamics. Deploying the system on the tables "claimed" by individual residents depended largely on their character, acceptance of the technology, and social connections. Although some residents need a longer time to accept new technologies, R2S still exhibited its capability to enrich their activities and foster new social interactions.

Based on our observations and analysis of participant feedback, we identified five usage patterns of socio-technical systems within public care environments. These patterns—*active use, adaptive use, passive use, opportunistic use*, and *non-use*— can provide insights into designing similar technologies in comparable contexts. The determining factors for these usage habits are associated with *residents' interest in the content or the system, their familiarity with the technology, the frequency of their visits to communal areas, their social relationships with other residents*, and *their characters*.

The participants' user experience of R2S was rated to be positive, underscoring the potential for such systems to be independently, freely, and enjoyably used by residents in public spaces when they are appropriately designed and introduced. The interviews revealed a set of factors that most participants valued, including *the ease of understanding and using, the freedom to select and share content, the functionality to compensate for their sensory impairments, the mechanism to provide real-time and practical information, the simplicity of physical and digital interfaces*, and *the capability to provoke discussions*.

The feedback from participants on their perceived social feelings indicates that although they did not experience very significant affective benefits, these benefits still far outweighed the affective costs. It shows that R2S was perceived as a gentle and user-friendly system, presenting a low risk of negative social experiences. The participants acknowledged the system's role as a valuable tool for enhancing mutual understanding, particularly benefiting those who lack consistent social companionship. Overall, participants expressed that they would gain more benefits from *using the system in group settings, engaging with content that matched their preferences*, and from *the collaboration or support of their peers.*

Implications for design and deployment

Drawing from the insights obtained from the R2S evaluation, a series of principles and implications are derived to guide the future design and implementation of social technologies in care environments. These key guidelines include:

(i) *Pay attention to the unwritten social rules*

The three types of tables we identified in Phase 1 indicate that the long-standing social habits of residents can form some unwritten social rules within public care spaces. Although these rules provide convenience for stable social groups, they also deepen the estrangement between them and other individuals. Therefore, before deploying a social technology system in nursing homes, designers and researchers need to understand and adhere to these

rules beforehand, as they will significantly impact the usage and social effects of the introduced system.

(ii)*Design for different types of users*

This study revealed that while not all residents were able to deeply engage with R2S, most of them could still find a way to interact with it, contributing to a generally positive user experience. Given this, we believe that socio-technical systems in care environments should be designed and deployed to accommodate all five usage patterns identified in this study. For example, to encourage active users, it is crucial to provide rich and continuously updated information. To facilitate adaptive users, the system needs to follow the residents' existing habits and interests. To support passive users, designers need to pay attention to the sensory impairments and audiovisual experiences of the viewers. To attract opportunistic users, designers, and developers can create more opportunities by adjusting the quantity and location of system units. Furthermore, it is necessary to provide detailed and easy-to-learn guidance in various ways. To accommodate non-users, it is essential to control the system's impact within a limited range to minimize disturbance to the surroundings.

(iii) *Provide extensive introduction services*

Providing diverse and continuous introductions is essential for the successful implementation of social technology in care environments. This study revealed that residents primarily learned to use the R2S system through introduction sessions, peer guidance, and embedded tutorials. Hosting regular introduction activities can effectively inform residents about new technologies. This approach also helps establish a group of users who can assist their peers. To initiate these activities, the system can be pre-deployed in public spaces with professionals present. To ensure effective dissemination, we recommend organizing introduction activities multiple times on a weekly basis to accommodate residents' personal habits. Our study showed that introduction activities effectively reached residents who frequently visit public areas, but their impact was notably less on those who tend to stay in their rooms. Caregivers suggested that new systems can be introduced during their large-scale recurring events. While not as impactful as direct human assistance, embedded tutorials still played a useful role in helping new users familiarize themselves with the system.

Limitations and future work

The primary limitation of this study is the relatively small sample size. This limitation arises from the nature of conducting field studies in real-world settings. While open testing allows us to observe genuine user feedback, it also restricts our ability to recruit a larger sample size. Despite efforts to engage a broader audience during the introductory week, the effectiveness of invitations and posters was limited, possibly due to the residents' generally inactive lifestyles. These individuals may require more time to become aware of, accept, and adopt new technologies. Although R2S was used by a relatively small group of participants, the study provided valuable insights, as the feedback from several participants was particularly indicative of broader trends. In future studies, we aim to reach more residents through more effective promotions and monthly-based deployment strategies. Additionally, due to research resource limitations, we deployed only one unit of R2S in the nursing home. Further exploration is needed to deploy such systems in various care settings and on a larger scale to validate the current results.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used ChatGPT to check for grammar mistakes. After using this tool/service, the author (s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Kai Kang: Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Bart Hengeveld:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Caroline Hummels:** Writing – review & editing, Supervision, Conceptualization. **Ye Kang:** Software, Data curation. **Jun Hu:** Writing – review & editing, Supervision, Methodology, Conceptualization.

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