Designing interactive public displays in caring environments: A case study of OutLook

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Abstract. In the past decades, we have witnessed a proliferation of interactive public displays for advertisement, entertainment and exhibition. We believe they also have great potential in the public spaces of caring environments if supported by related knowledge of design and research. This study explores how to design and evaluate interactive public displays in caring environments with a case study. In this paper, we describe the design process of OutLook, which is part of an initial participatory system specially designed for nursing homes to explore the possibilities of connecting people. It aims to enhance nursing home residents' social wellbeing through a "look-outside" and a "postcard-sending" metaphor. A field trial was performed to assess the effects of OutLook on nursing home residents' social behavior and feelings of connectedness. Key design factors for the effects and lessons learned were proposed as regard to design concept, design ideation, form of design, content, interfaces, interactions and field trial.

Keywords: Interactive public display, nursing home, case study, ageing society, social interaction

1. Introduction

Population ageing has led to increasing needs of care facilities, and the demand for high-quality institutional care of the aged is likely to continue in the future [26]. With the effort of the research and practices in architectural and space design of caring environments [33], most nursing homes have developed into an integration of private rooms and public spaces [3]. Since most old people move to nursing homes because of physical or mental degradation, they spend a great proportion of their time within the boundary of care homes [8]. Significant associations have been found between physical caring environments and the residents' quality of life [33]. The shared areas within caring environments, collaborating with professional care services and programmed activities, provide the residents with opportunities to have diet, entertainment and social interactions with each other [19]. However,

in spite of the increasing standard of facilities and creative activities in care homes, many surveys reported that most residents spent a large portion of their day in their private rooms, sitting, alone and inactive [21,32]. Besides, compared to those who live independently, nursing home residents spent less time in social activities [2]. Such inactive lifestyle and the lack of social interactions has been proved by numerous studies to have a negative impact on the residents' physical and mental wellbeing. There is a close relationship between sensory impairments of nursing home residents and their little time spent in activities and social engagements [41]. Significant variation between depressed and non-depressed residents has been found in their frequency of attending activity programs and organized activities [48].

However, although a lot of organized activities have been proven to be effective and many residents claim to enjoy such activities, there are still inevitable problems [15]. Firstly, it calls for strong human, material and financial support. Secondly, such activities are

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held in the public spaces within care homes only on an intermittent basis, which lacks continuous influence on residents' social feelings and behaviors. From the perspective of individual resident, they have to entertain themselves in the rest of their time, which can easily lead to an inactive lifestyle. However, even if the activities could be held continuously throughout the day, the residents would feel intrusive if these activities keep occupying their public areas. Thirdly, since nursing home is a distinct institutional social space where people from different backgrounds live together, activities based on certain themes are difficult to meet the variety of needs. Last but not least, activities are usually led by caregivers and passively followed by residents. Researchers in this field argue that residents also need the freedom to choose whether to be social or not at a certain moment in order to maintain a sense of individual control [11]. The provision of social opportunities is more beneficial to them than enforcing social interaction. Therefore, more innovative approach is needed to enhance the nursing environment settings to facilitate the elderly to have meaningful activities and social interactions rather than simply improving hardware facilities or organizing planned activities.

In the past decades, we have witnessed a proliferation of digital displays in public spaces for advertisement, entertainment and exhibition [4,9,43]. With the maturity of sensor technology, social networking and information technology, there are an increasing number of public displays evolving from presenting predetermined feeds to interactive platforms. Diverse social interactions of nearby users can be triggered. What's more, enhanced by information and communication technology (ICT), the platforms can also bridge the distance between people to create a sense of community [45]. We believe interactive public displays have potential to be applied in public spaces in caring environments, not only because they can continuously detect behavior of bystanders and give feedbacks, but also can be intermediary agents to support multi-user interactions simultaneously. Furthermore, the content and interfaces of the public displays can be changed with low effort to meet the various needs of different nursing home residents. Therefore, interactive public displays can perhaps be a more fluid approach to enhance the public spaces within caring environments by promoting social interactions and meaningful activities throughout the day. However, most of these applications are designed for the younger generations. When we are benefiting from advanced technology, numerous nursing home residents are becoming increasingly isolated from their children, neighborhood and outside word [35]. Boredom, loneliness, and helplessness are reported as common problems in caring environments [14,34]. Since the elderly have long been playing a minor role in research and design on information needs and usage of technology, it is unwise to directly transplant traditional interactive public displays on the market to nursing homes [35]. Thus, there is a strong need for the research and design of interactive public displays in caring environments.

2. Related work

Large LCD screen was the typical form of public displays in the early stage. It was designed as a one-to-many tool to broadcast information by presenting digital texts, photos and videos [31]. With the development of electric display, sensor technology and ICT, current public displays are becoming interactive to engage multiple users by eliminating time, space and social barriers. In the past few years, we have witnessed the success of interactive public displays to attract people in the same space to interact with each other simultaneously [9,28]. They serve as an agency to connect people nearby by continuously presenting real-time feedbacks [1,36,38]. In these cases, LCD is no longer the only way to display. Projection, lighting, shape-changing mechanical installations are now a growing community [17,22,28,29,42]. Bedsides, interactive public displays are also designed to facilitate tasks such as schedule making, memory recording and collaborative working within organizations [12]. For the people belonging to one community, they are free to post their information when they pass the public area or they can even do this remotely by individual devices at anytime [20]. Such social network can not only offer awareness of peers' activities, but also enhance a sense of belonging [23]. There are also explorative design practices aiming to establish new social contacts for strangers. Multiple displays can be installed in different areas to break spatial and social barriers between group members [36].

Although there are numerous examples of interactive public displays designed for communities, few of them can be applied in caring environments because the elderly are supposed to have a low acceptance and ability to use new technology [39]. Therefore, they may become more isolated with the growing digital

divide. To narrow this gap, researchers are searching ways to provide more friendly interfaces for the elderly. Systems that render their services in a sensitive and responsive way and are unobtrusively integrated into daily environment are referred to as ambient intelligent (AmI) [5]. It has been recognized as a promising approach in the domain of Assisted Living [24]. Although Ambient Assisted Living (AAL) is very important in the area of long-term care services, most of the design works and research are focused on physical care such as autonomy enhancement and emergency precaution [37]. Mental care services, especially social wellbeing in caring environments, have only been explored by some studies. Furthermore, a great part of these studies discussed about how to maintain distant intimate relationship between family members with ambient displays in the elderly's private rooms [6,7,13,47]. But, as mentioned above, we believe there is a stronger need to design interactive displays in the public spaces of caring environments because social relationships formed with other residents is a much stronger predictor of depression and loneliness than social relationships with friends and relatives from outside the institution [16]. Currently, only a few studies start to research how to design interactive public displays in long-term care facilities. The major efforts of these design and studies are paid to dementia patients. The public displays serve as a content-assist tool for animal-assistant-living therapy, reminiscence therapy and eco-therapy [18,46]. Most of the design cases for residents with lucid minds lack systematic research and evaluation processes. Furthermore, in the general fields of designing interactive public displays, even though some design requirements have been contributed, it is still necessary to generate knowledge in this specific context [30].

3. Design of OutLook

3.1. Preliminary study

In order to have a specific context to design, we chose a typical Dutch nursing home in Eindhoven. A preliminary study was conducted in the early stage of design. The purpose of this study was to have a basic understanding of the physical caring environments, residents' daily habits and their social status.

This facility belongs to Vitalis Care Group which is a professional organization providing living, treatment and care services for the elderly. The nursing home
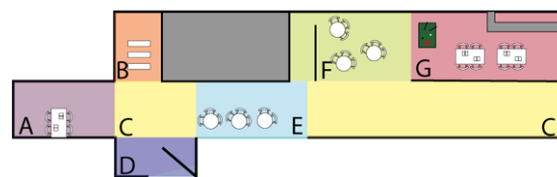

Fig. 1. The layout of the public spaces of the nursing home (A: Reading area, B: Library, C: Hallway, D: Gate, E: Leisure area in the hallway, F: Leisure area next to the canteen, G: Canteen).

consists of private rooms, public spaces and close areas for dementia patients. The public spaces include a restaurant, a library, several hallways and leisure areas to satisfy daily demands of residents (Fig. 1). Programmed activities and multiple levels of care including independent living, assisted living and behavioral care units are also offered.

The preliminary study was composed of an unstructured empirical observation and interviews with caregivers. The observation was conducted by two trained research assistants. They walked around the public areas and watched the residents' daily behavior from breakfast (8:00 AM) to dinner (6:00 PM) for one week. A report was submitted in the end. For private and ethical issues, recording videos was not allowed. The observers could only take notes if necessary. According to the report, a great proportion of the residents stuck to regular daily routines. "Always the same group of people did the same thing at the same place." The observers recalled afterwards. The canteen (Area G) and the leisure area in the hallway (Area E) were the main public spaces they would like to stay. Although there was an age-oriented mini library and a reading area, few residents spent long time there. They often chose to sit in the canteen reading newspapers and magazines. The canteen not only served as a place for eating and drinking, but also was a primary area for entertainments like games and organized activities. The leisure area in the hallway was another popular place where there was a large window through which the elderly could look outside. We found a very common phenomenon that many residents spent hours to look outside and do nothing every day (Fig. 2), which later became one of our design inspirations. The leisure area (Area F) next to the canteen was much less popular. This was where the residents wanted to stay when they had family visits because this area was relatively quiet and suitable for private conversations. Most of the residents just passed this area to enter the canteen from the hallway.

Fig. 2. The nursing home residents spend hours sitting and looking through the window every day.

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

3.2. OutLook design concept

Based on the preliminary study, we designed a participatory system to enhance nursing home residents' social wellbeing (Fig. 3). The system consists of two parts: one is a group of camera kits called ViewBricks for people outside nursing homes to share real-time image sequences from different local places. The second part is OutLook, which is a series of gallery-like public interactive displays (Fig. 4). It continuously displays the shared contents in an ambient way in public spaces of care homes and triggers further social
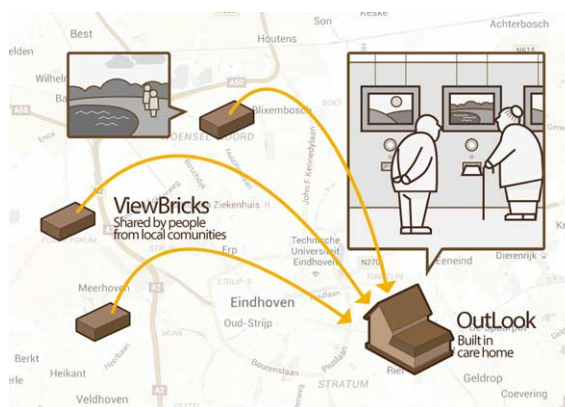

Fig. 3. An overview of the smart participatory system: ViewBricks and OutLook.

Fig. 4. The design of OutLook and Viewbricks.

interaction of residents through a "postcard-sending" metaphor (the concept video has been uploaded online: https://www.youtube.com/watch?v=4KRRUduefFQ&t=5s).

To run the system, people from local communities are assigned with ViewBricks and encouraged to put them wherever they would like to share. All they need to do is to turn on the camera kits, let them face the view stably and then leave. ViewBricks keep taking photos and upload them automatically (1 picture per minute). In the public spaces of a nursing home, Out-Look keeps receiving the image sequences from cloud server and displaying them in an ambient way. It can detect the presence of nursing home residents passing by and attract them by playing a time-lapse animation to demonstrate the changing sceneries in the past 2 hours (Fig. 5). If the residents enjoy the real-time view, they can choose to print it as a postcard by pressing the button under the display and share it with others (Fig. 6). The "postcard-sending" metaphor transits the interactions from digital languages to physical ones, and provides physical evidences to trigger social interactions between residents and other people.

Our design motivation was to make some differences of residents' repetitive life, trigger their social interactions and enhance their feelings of connectedness. As mentioned above, the interactive public displays can be a platform to connect people by breaking space, time and social barriers. OutLook was inspired by the residents' habits of looking out through the windows in our preliminary study. Due to their physical degradation, many of them can hardly go traveling for a long time or to a far destination. OutLook would be a way to bring the outside world into the nursing home by displaying real-time images. We also hope social interactions could not only be triggered when the residents watch together, but also be sustained by the physical sharing of postcards. The implementation of the whole system was introduced in our previous paper [25].
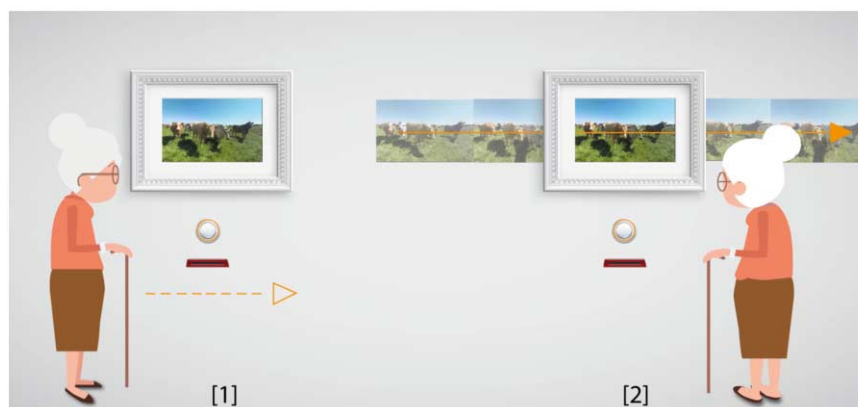

Fig. 5. OutLook would start a time-lapse animation when it detects people standing in front of the frame, and show the changes of scene in the past 2 hours.
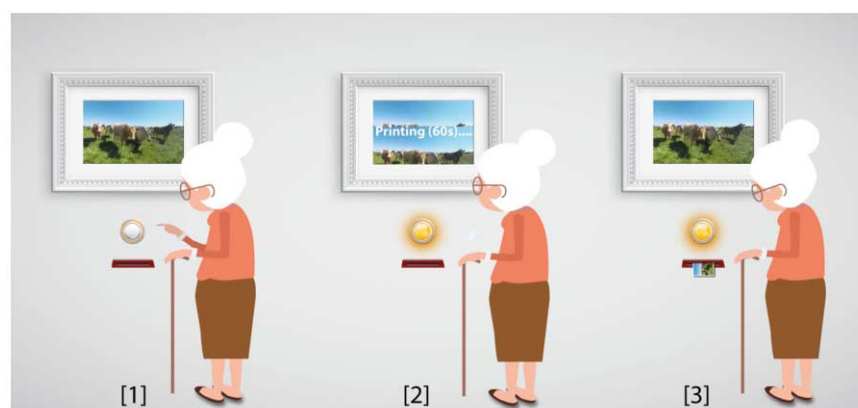

Fig. 6. From digital sharing to physical sharing by pressing the button of OutLook.

4. Field trial of OutLook

4.1. Settings

4.1.1. Location

In order to maintain consistency, we decided to install OutLook in the nursing home where we conducted the preliminary study. We chose to install it in Area F against the wall facing the canteen (Fig. 7). This location was selected based on the preliminary study. Firstly, the leisure areas were more open to build social contacts between acquaintances or strangers. Secondly, compared with the leisure area in the hallway, Area F has more open space for residents to walk around. In addition, this area used to be less popular, more significance would perhaps be found if the residents were attracted by OutLook.

4.1.2. Interface

Considering the acceptance and ability of the elderly, the physical interface was designed like a gallery with three white photo frames. Simple and clear was the criteria when we designed the digital interface. Most of the time, OutLook just displays the latest image. When it plays the time-lapse animation, there would be a caption "Two hours ago..." on the lower-left corner. When user presses the button, the light inside the button would be turned on, and there would be another caption "printing the postcard" with a countdown clock from 60 seconds.

4.1.3. Content

Although the original design concept was to assign ViewBricks to random local people, the research assistants did this job during the field trial. Three themes (animals, people and landscapes) were chosen to attract the nursing home residents with different preferences (Fig. 7). The camera kits were put in three typical local places including a farm, a university and a park. For privacy and security reasons, the cameras were located far from people so that their faces could not be recognized.

4.2. Procedure

To assess the influence of OutLook on nursing home residents' social behaviors and feelings of connectedness, a field trial was conducted. The whole study consists of four stages: Usability Test, Baseline, Introduction and Intervention (Fig. 8).

Before OutLook was installed in the nursing home, it was tested in the public space of Industrial Design Department of TU/e (Technology University of Eindhoven) for one week. This test was mainly focused on usability. We put ViewBricks in a little park of the campus to collect images. To simulate the context in the nursing home, OutLook was put in the corridor between the canteen and offices where staff and students usually passed by. The system kept running at least 2 hours a day during working hours. Unstructured observations were conducted to find out possible problems. Besides, we invited 8 nursing home residents to come

Fig. 7. The prototypes of OutLook in Area F display different themes (animals, people and landscapes).

and experience. Informal group interviews were conducted to get their initial feedbacks including usability, user experience and location preferences. Some parameters and algorithms were then refined based on the results of the observation and interviews.

Usability Test was followed by Baseline. The purpose of Baseline was to collect residents' behavior data in Area F by structured observation. In this stage, we recruited the same observers from the preliminary study because they were familiar with the context. The observation lasted one week from 2:00 PM to 4:00 PM every day because it was the period when most of the residents came to the public spaces for entertainment.

After Baseline, OutLook was installed in one night without interfering residents' daily life. Considering the elderly's limited acceptance and ability to use tech-

nology, we hosted an introduction activity one week before Intervention. We invited the 130 residents mentioned in the preliminary study by sending invitations in their mailboxes. Twenty-two residents came to this activity. The whole session lasted from 2:00 PM to 4:00 PM. It started with an explanation of the design concept and a demonstration of typical scenarios. After that, the residents were encouraged to ask questions and experience the prototypes (Fig. 9).

Intervention started one week after Introduction and lasted 5 weeks in total. We kept the system running on from 1:30 PM to 4:30 PM everyday in this stage. The structured observation was conducted by the same observers with the same measurements as Baseline (from 2:00 PM to 4:00 PM). In order to investigate how the effects changes as time passed, the observation consisted of two phases. The first week of Intervention was called Phase 1 and the third was called Phase 2. In the following two weeks after the observation, the interviewers were guided by the observers to find users as many as they could to participate in the interview.

4.3. Measurement

Since the dawn of interactive public displays, there has long been a conflict between the intrusiveness of evaluation methods and the intention to keep the public display at the periphery of the user's attention. It is still lack of research discussing how to evaluate general interactive public displays in real-world settings [27]. We believe the evaluation methods vary in different contexts. In this study, we explored the potential evaluation methods in caring environments.
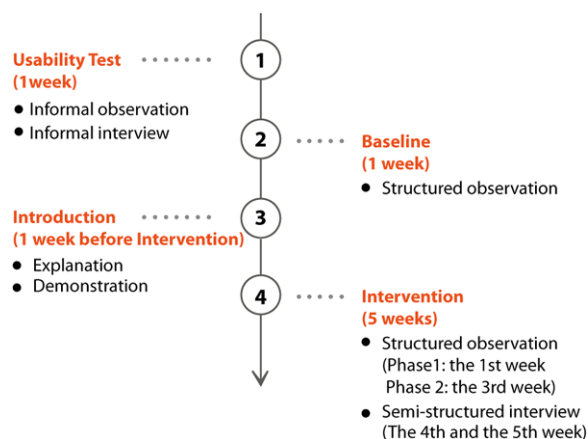

Fig. 8. An overview of the research procedure.

Fig. 9. The nursing home residents trying OutLook in the introduction activity.

We designed OutLook with the following hypotheses: after OutLook was installed in Area F, more residents were expected to stay in this Area; The residents were expected to stay longer in this Area; The residents were expected to spend more time in social interactions in this Area. The residents would feel more connected, not only to each other, but also to outside people and locations.

To verify our hypotheses, objective and subjective measures were adopted. Objective observation, as a technique of behavioral assessment, was used to measure the residents' behavior change caused by OutLook. Baseline observation and intervention observation was conducted to compare their behavior before and after OutLook was applied. To minimize Hawthorne effects and gather their real reactions in the public space, we did the observation in real-world settings rather than lab environment [44]. Although much more completed and accurate raw data could be gathered by video recording, we collected the behavior data by taking notes out of ethical concerns [40]. We made several references to the study of McClannahan & Risley, which collected descriptive data on nursing home residents' rates of verbal and motor behavior [26]. Unlike their research to observe all the public areas, we only observe Area F. To avoid disturbing residents' activities in this area, the observers kept sitting at the corner of the canteen (Fig. 10). Based on the report of the preliminary study, we summarized their basic daily behaviors and potential interaction behaviors. Theses behaviors, together with the three displays and the tables in Area F were recorded as alphanumeric codes (Fig. 10). After the one-week observation in the preliminary study, the trained observers can recognize most of the residents appeared because of their repetitive daily routine. They were assigned to unique names for identification. To record residents' detailed behaviors in the two hours, the interval between each note was 1 minute. Usually, in general observational studies, the interval was much longer because it was difficult for the observers to record multiple subjects' changing behaviors on such short notice [21]. However, in this specific context, it was feasible because Area F was a much less popular space than the canteen or hallway. It was a simple and stable environment. Besides, most of the residents' behaviors were not complicated and their movements were slow. Therefore, 1 minute was enough for the observers to take notes and gather detailed data.

To investigate the effects of OutLook on residents' subjective feelings, post-trial interviews were performed. The interviews were held using a general interview guide to maintain consistency in the topics covered, but at the same time they allowed the interviewer to explore and probe further into particular sub-
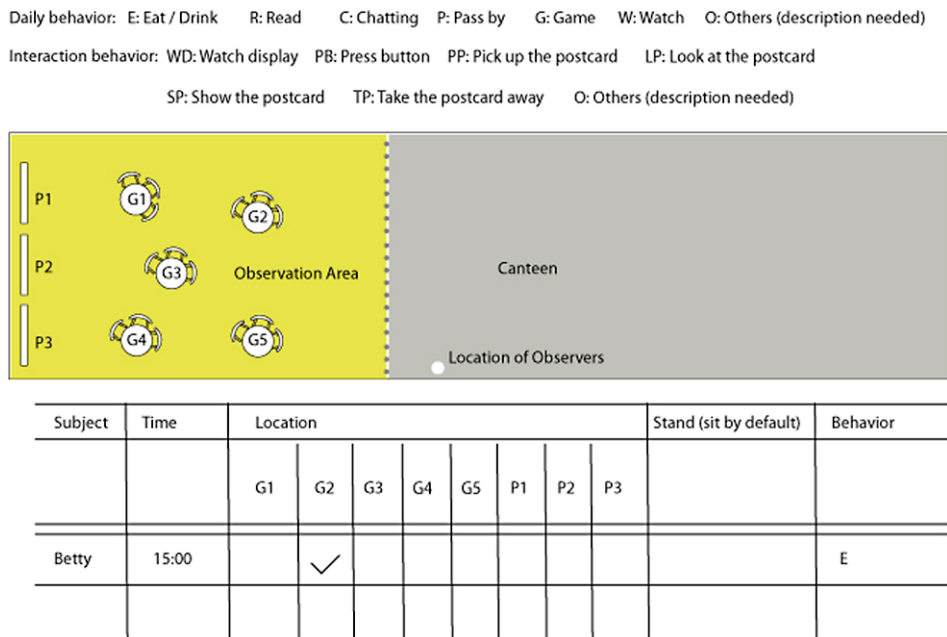

Fig. 10. A sample check sheet for collecting behavior data.

jects [36]. The interview guide included the following primary topics:

1. The residents' usage and perception of OutLook (How do the residents understand the concept?)
2. Overall use experience (positive or negative)
3. Feeling of connectedness (Did OutLook bring new feelings and make them feel more connected to each other, outside people and locations?)

5. Result

5.1. Result of the observation

5.1.1. Evaluation of the hypothesis
– Hypothesis 1: More residents were expected to stay in Area F.

To examine this hypothesis, the total number of the residents stayed in Area F through the observation period per day was compared between each session. Those who just passed this area or stayed less than 1 minute were not recorded. As shown in Fig. 11 and Fig. 12, there was an overall improvement from Baseline to Intervention. One-way ANOVA was used to test if there were statistically significant differences between each session. From the comparison between Baseline and Phase 1, there were significantly more residents coming to this area in Phase 1 ($p < 0.05$). Although the average total number per day in Phase 2 still showed an increase than Baseline, it was not sta-

Fig. 11. The total number of the residents stayed in Area F through the observation period per day in Baseline and Intervention.

tistically significant ($p = 0.15$). Compared with Phase 1, the number started to decrease in Phase 2. It seemed that the attractiveness of OutLook started to decline after Phase 1. However, the decrease was not significant ($p = 0.29$).

Besides the total number, we were also interested in how many residents stayed and used OutLook in Phase 1 and Phase 2 (Fig. 11). The term 'use' means stayed in front of OutLook watching the displays or pressed the buttons. If we compare the percentage of the users in total number each day in Intervention, the average percentage was 51% and no significance was found between Phase 1 and Phase 2 ($p = 0.69$). Therefore, on average, over half of the residents in Area F had interacted with OutLook everyday in Intervention.

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

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

The duration of the residents' stayed in Area F can be calculated based on the observation logs. To verify this hypothesis, the total time spent by every resident in Area F through observation period per day was added up (Fig. 13). As can be observed in Fig. 14, similar to Hypothesis 1, the average time spent by the residents each day also had an overall increase from Baseline to Intervention. Unlike the attenuation trend in Hypothesis 1, the average amount of time in Phase 2 still kept rising, but the data in Phase 2 had a much higher standard deviation than Baseline and Phase 1, which means there was a big difference between the data of different days in this session. Besides, the improvement in Phase 1 was close to reach significance ($p = 0.09$). No
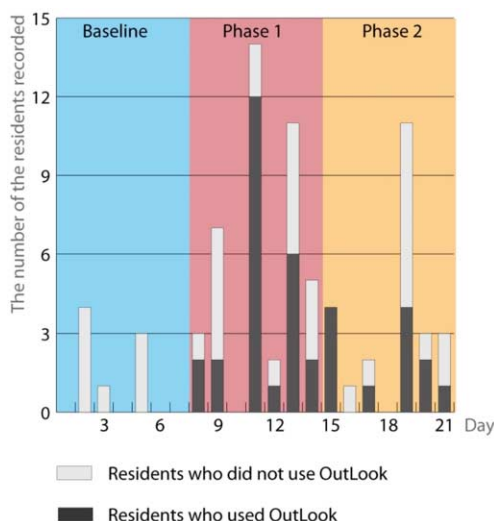
	Baseline	Phase 1	Phase 2
Sum	8	42	24
Mean	1.14	6	3.43
SD	1.68	5.03	3.6

Fig. 12. The sum represents the total number of residents in Area F through the observation period per week. Mean = the average number each day; SD = standard deviation.
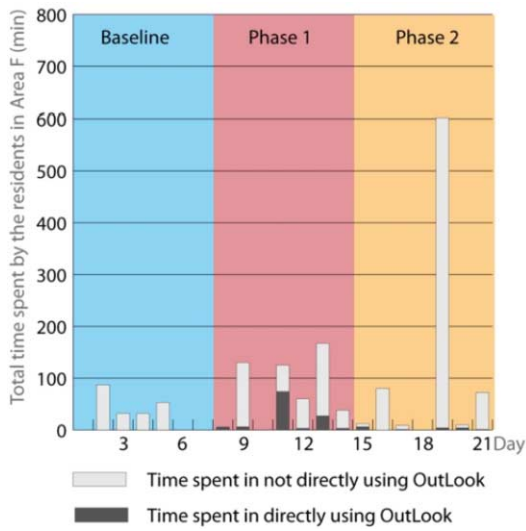
Fig. 13. The total time spent by the residents in Area F through the observation period per day in Baseline and Intervention.

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

Fig. 14. The sum represents the total time spent by the residents in Area F through the observation period in the whole week (min). Mean = the average time spent in each day (min); SD = standard deviation.

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

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

Fig. 16. The sum represents the total social time spent by the residents in Area F through the observation period in the whole week (min). Mean = the average social time spent in each day (min); SD = standard deviation.

significances were found between Baseline and Phase 2 ($p = 0.3$) or Phase 1 and Phase 2 ($p = 0.6$).

To further explore how the residents spent their time in this area, we were also interested in the proportion of their time spent in directly using OutLook. From Fig. 13, we can find out the average proportion of the residents' time spent in using OutLook was 29.37% in Phase 1 and 17.19% in Phase 2. There was no significant difference between the two sessions ($p = 0.55$).

So generally, although not stable, we can see an increase of the resident' time spent in Area F since Intervention, which preliminarily proved our hypothesis. However, they spent a small portion of their time in directly using OutLook. Although we assume some residents may spend their time in watching OutLook in a distance, we could not directly conclude from the ob-
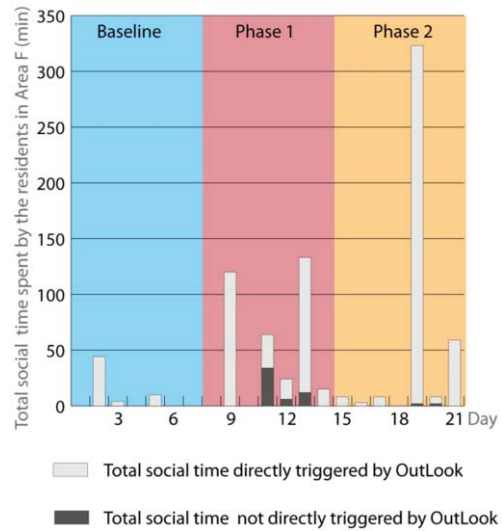
servation. This assumption may be confirmed in the interviews.

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

The social interactions observed mainly included talking, listening to caregivers (including family, staff or volunteers) reading, sharing photos and postcards. To measure this, we added up the social time through the observation period every day in Area F (Fig. 15). As we can see from Fig. 16, the average time spent in social interactions per day sharply went up by 83.7% (Phase 1) and 85.8% (Phase 2) after OutLook was installed. The increase in Phase 1 nearly reached significance ($p = 0.08$), and there was no statistically significance between Baseline and Phase 2 ($p = 0.29$) or Phase 1 and Phase 2 ($p = 0.88$).

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

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

5.1.2. Location analysis

As mentioned above, we also recorded the locations of the residents. Fig. 17 describes where the residents spent their time in each session from a holistic perspective (one dot means one minute). Generally, we can see that the residents tend to spend more time in this area in Intervention. But as time passes, the time spent in front of OutLook showed a decline trend. Within Phase 1 and Phase 2, the time spent in front of each display was at a similar level. Besides, we can clearly see that Table G5 was the most popular place they would like to stay in both Baseline and Intervention. According to the report, the main reason was that G5 was close to the canteen. It was difficult for the elderly to order something to drink if they sat far from the waiters in the canteen. Although G2 is also close, it was blocked by a wall. It perhaps could explain why G2 was one of the most unpopular choices for the residents.

5.1.3. Content analysis

We also wanted to explore whether the theme differences would affect residents' choice to print postcards. Fig. 18 illustrates how many times the button of every display was pressed in Phase 1 and Phase 2. From the observation logs, we found even though some residents pressed the button out of curiosity when they passed the area, they did not have patience to wait for the postcards coming out. From the chart, we can clearly see a radical decline in Phase 2, there was only one resident pressed the button once in the whole week, and he did not even wait for the postcard. Within Phase 1, there was not significant difference between each theme. Generally, most residents would like to press the button of P2, but nearly half of them did not wait to take away the postcards. The postcards with pure landscape seemed more attractive to keep.
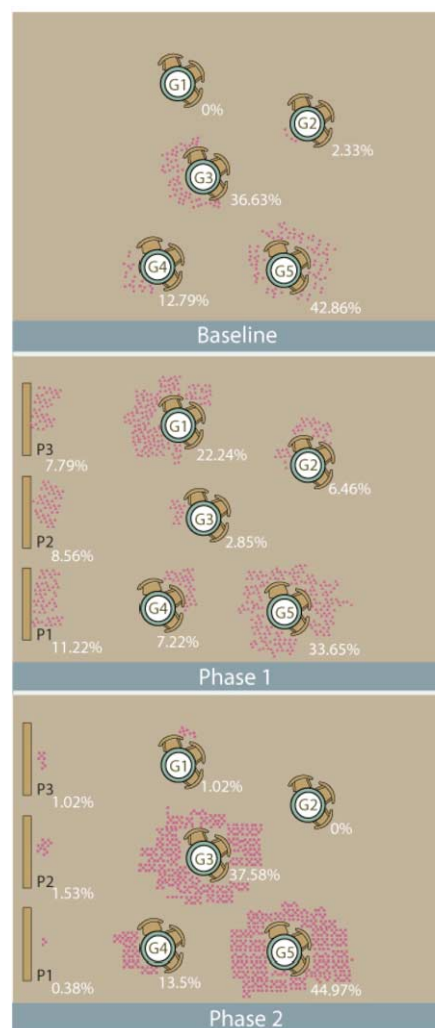

Fig. 17. The distribution of the time spent by the residents in each spot of Area F in the whole session of Baseline and Intervention.

5.2. Result of the interview

Thirteen residents in total agreed to participate in the interview, ranging in age from 62 to 90 (Mean = 81), four males and nine females. Among the participants, eight residents (three males and five females) used OutLook according to the observation logs. We classify them into Group 1. Two residents (two females) participated in the introduction activity, but did not use it after that (Group 2). Three residents (one male and two females) had neither joined the introduction activity nor used OutLook, they were chosen randomly in the public spaces of the nursing home (Group 3). The participants were first asked their basic information including their job background and their usage of technology. According to their feedbacks, the main in-
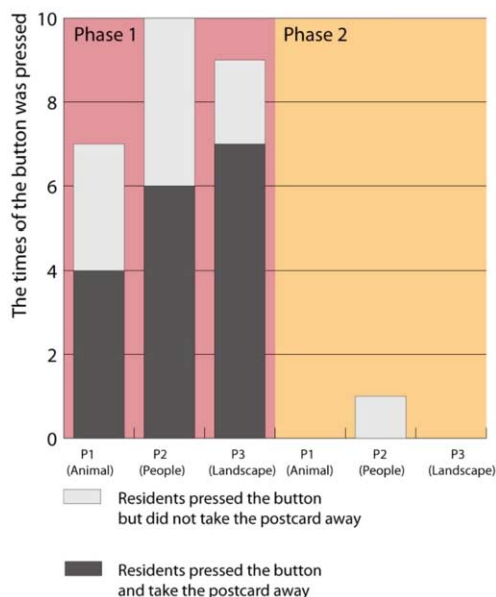
Fig. 18. The times of the buttons pressed by residents in Phase 1 and Phase 2.

formation sources of were television and newspapers. Only one of them with an engineering background (S1, male, age 77) can use computers and smart phones.

5.2.1. Usage and perception of OutLook

To investigate how the participates used and understood OutLook, they were asked whether they had noticed the existence of OutLook. All the residents in Group 1 and Group 2 said yes while all the 3 residents in Group 3 said no even though they passed this area regularly every day. Among the 10 participants who noticed OutLook, 9 of them had joined the introduction activity, which was important for them to have a general understanding of how it works and motivated them to use afterwards. One female in Group 2 (S2, age 62) claimed that she still had not understand the intention although she had joined the introduction session and the other one female (S3, age 90) said she never touches unfamiliar devices and is afraid to make mistakes, so they refused to use OutLook. The only one participant who used OutLook without attending the introduction was S1. He was attracted by the displays when passing by. He could also well explain the design concept without any instructions. However, for the most of the participants in Group 1 and Group 2, it was difficult for them to retell the whole design concept even though they were clearly explained in the introduction activity. The most obvious feature of OutLook for them was printing postcards. Only three of them knew OutLook displaying real-time images.

5.2.2. Overall use experience

Before evaluating the residents' use experience, we explained the design concept again to make sure every participant could totally understand it. All participants in Group 1 expressed positive use experiences. One participant of Group 2 and all the 3 participants of Group 3 also showed positive attitude to OutLook. One of them said: "I find it fantastic to watch something happening. That, I think, I find that is very beautiful!" The one female (S3) who refused to touch unfamiliar devices still showed very little interest. She was the oldest of all the interviewed participants (age 90). She had been leading a very inactive lifestyle in the nursing home. She stated: "I just watch TV and also do nothing." "I do not think too much when I sit downstairs. No, I am always upstairs in my own room." She came to the public spaces mainly for eating. Although she showed a great interest in one display with animals, she was afraid of any technical devices. She once had her son to press the button but never did that when she was alone. We tried to design public displays in caring environments to be friendly, simple and clear to the elderly, and most of the interviewed participants were very satisfied to the physical interfaces. They described OutLook as "paintings" and "photo frames", and most of them thought the buttons were very clear to them. However, they were also worried some other residents may be confused because their acceptance of technology varies greatly depending on their age and mental conditions. As for the digital interfaces, four participants of Group 1 strongly suggested it would be very helpful if some explanations could be added. They wanted to know when and where these photos were taken. Two participants of Group 3 also suggested, for those who did not attended the introduction activity, some booklets could also be provided nearby to introduce the design concept and guide them to use. Seven of the eight participants in Group 1 had pressed the button, among which six participants waited until the postcards came out. One female (S4, age 84) pressed the button three times when she finished her drink and went back to her room. But she left every time without waiting for the postcards. She thought the system was of great fun to watch, but felt frustrated when no immediate feedbacks. Most of the seven participants who got the post cards chose to keep the postcards. Only one female (S5, age 79) sent it to her friend living abroad. She and another male (S6, age 65) had a hobby to collect photos and postcards. They came to this area regularly to print postcards they liked. The other 5 participants usually used

OutLook on their way to the canteen or back to their room. Most of them pressed the button once or twice in Phase 1, but in Phase 2, they mainly stood in front of it or sat in distance to watch, which was consistent with our findings of the observation.

5.2.3. Feeling of connectedness

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

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

As mentioned above, in our field trial, we were interested in residents' feeling of connectedness in three aspects: the connection to the locations displayed on the screens, to the people who shared the images and to other residents. Generally, all the interviewed participants could feel a sense of connectedness more or less to the locations. Five of them felt very connected because they could recognize the locations that recalled their related memories. One of them (S1) stated: "We lived in North Eindhoven, so we went walking regularly. And uh, the university, yes, we have so often cycled through." They emphasized the importance of familiar locations. They felt like they could still do something when they were younger. Some participants who could not recognize the locations felt a little connection when they found the images are real-time. Only 2 participants felt directly connected to the people who share the views. Most of them said it was difficult to connect to someone they did not know or they could not see. Besides, the feedbacks from the interviews confirmed our result from the observation, which is, they did not spend much time in using OutLook every time and few social interactions took place when they were using it. Only 2 participants in Group 1 talked to other residents and shared postcards when they were using OutLook. Most social interactions took place after they left this area. Six of the eight participants in Group 1 said they talked to others after they used Out-Look. Three of them talked to their family first and then to other residents. The other three participants talked to other residents directly. Two of the six residents liked it very much and recommend it to others. The topics are mainly focused on the intention of OutLook, how to use, printing postcards and the locations displayed. Most of them admitted that there was not much to talk about except they had postcards to share around or they were from the same community related to the locations on the screen. However, most of them would like to keep the postcards in their own rooms. The effect of OutLook to eliminate social barriers and trigger social interaction seemed difficult to sustain, especially when they left the area. Therefore, only one participant (S7, female, age 88) felt an obvious improvement of their social connectedness to other residents.

5.2.4. Other findings

Besides what mentioned above, most participants had the awareness that they should not sit in their rooms for too long, some of them kept complaining about the repetitive life in the nursing home, most of the time they had to find something to do themselves or they would be alone all day and do nothing, which was consistent with our findings of the preliminary study. They said: "I find it is interesting, that's what all here and there are the same every day." OutLook had given some relief to this situation by displaying real-time images in an ambient way, which created awareness of presence for the residents. Three participants suggested OutLook should be moved to other areas with more people, so that the residents would have more time to use and discuss. One participant also indicated that we could design many displays and distribute them in multiple spots to connect the residents in different areas. In addition, although we did not see big difference between their preferences for the content of displays, but from the interviews, they expressed much more love of photos with nature and animals than people. It was interesting because according to our observation, postcards with people were printed the most times. We assumed that images with people would be easier to arouse residents' curiosity. There could also be other reasons such as the order we allocated each display or the image quality.

6. Summary and discussion

Previous studies have proved that extended periods of inactivity of the nursing home residents can acceler-

ate the process of degradation. Organizing regular programs has been a common solution, but it lacks continuous effect in the rest time of the day. We believe interactive public displays can play an important role. The present study demonstrated the design process of OutLook and the research process of a field trial. The main purpose was to investigate the potential effects of the interactive public displays like OutLook on the nursing home residents' daily behaviors and their subjective feelings. This case study also aimed to explore possible methods to design interactive public displays and evaluate them in real world settings. The methods adopted in the design process consist of unstructured observation and interviews, while structured observation and semi-structured interviews were used in the field study. The result of the observation indicates that OutLook can effectively influence the residents' behavior. However, since the field trial was performed in a total open area, the data could be possibly interfered by external factors as well as other environmental conditions, which may increase volatility and hard to reach statistical significance. To be specific, OutLook was successful in attracting more residents to Area F that was very unpopular before. In the first week, there were significantly more residents came to this area, but the attractiveness started to decline when it came to the second week. Furthermore, OutLook attracted over half of the resident stayed in Area F to use in both Phase 1 and Phase 2. Beside, a radical improvement of the average total time spent in Area F each day was been found in Phase 1, and the upward trend continued in Phase 2. However, the residents spent a very little portion of their time in directly using OutLook, and as time passed, this proportion was getting less, which was confirmed by the interviews that in the later stage, the residents preferred to sit at the tables watching the displays in distance instead of in front of OutLook. This could also explain why the location analysis showed that the increased time was more likely to spent around the tables rather than OutLook. As for their subjective feelings, the majority of the interviewed participants expressed positive overall use experience. Besides, most of them agreed that OutLook had brought new feelings not only because it was fresh to them but also it displayed real-time images and changed all day. Almost all the interviewed participants felt a sense of connectedness to the views showed on the screens, but few of them felt connected to the people who shared the images. In addition, due to the short duration of the interaction with OutLook, social interactions between the residents could hardly take place when they were

using it. Most social interactions triggered by OutLook took place after they left the area, but this kind of interaction could hardly go further or sustain without the presence of OutLook or postcards.

This case study was the beginning of a series of design studies aiming to propose guidelines and requirements for the development, design and research in caring environments. Although many findings from HCI can be applied to interactive public displays, simply guaranteeing utility, usability, and likability may not be enough. There have been also some requirements proposed for interactive public displays, but we believe more efforts need to be paid in caring environments with specific context and target group.

From this case study, we would like to speculate on some key design factors of OutLook, and also point out some lessons we have learnt, which would be verified in our future research.

– The design concept should consider the common interests of most residents:

Our design was inspired by a phenomenon observed in preliminary study that the residents liked to look out through windows. According to the results, OutLook could attract many residents to come and watch. But, only those who loved collecting postcards came to press the buttons regularly. We believe interactive public displays in nursing homes should not just cater to the hobby of only one group. More open platforms should be designed to cover their common interests. Residents could also be empowered to be part of the content producers, which is essential for long-term use. Therefore, extensive user study on their specific habits, interests or cultural background could be included before designing.

– The whole design process should highly involve the residents:

We conducted unstructured observations and interviews in the preliminary study, which proved to be very helpful to understand our target group and generate suitable design concepts. We also conducted an informal group interview during Usability Test. However, the involvement of the residents was not enough between the two sessions. Besides, the residents that we invited to join Usability Test were active and in relatively higher mental level. Although we aimed to design for general residents with lucid minds, their ADL level (activities of daily living) still varies greatly, which would probably lead to a gap between our design intentions and their perceptions. For ex-

ample, many residents who had used OutLook could not realize the images were real-time even though some of them had participated the introduction session. Therefore, the residents should be involved in various ways as design ideation progresses. For example, co-creation methods and quick & dirty approaches could be adopted in the very early stages [10]. Then, utility, usability, and likability of promising prototypes could be tested individually. Social aspects could be investigated by group tests before conducting field trial.

– The form of design should follow the residents' daily routines:

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

– The content to be displayed should keep changing in an explicit way:

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

– The interfaces should be friendly, explicit and inviting for the elderly:

The physical interface of OutLook was complimented by most of the participants from the interviews. They expressed their love to the low-tech and decent appearance with photo frames and wooden material.

The button was simple and clear to most of them, but it also created a feeling of machine, which was not friendly to those with low acceptance of technology. As for the digital interfaces, using slideshows to attract residents was not as inviting as we expected, many participant did not even noticed it. The digital interface designed for elderly should be more explicit and inviting.

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

OutLook was a success to attract most of the residents nearby to use mainly because it required low effort to interact, however it failed to sustain the interactions. The typical scenario was watching, pressing the button and leaving. The result showed that the social interactions triggered after they use OutLook could hardly become meaningful and sustainable. In addition, although the interactions required low effort, for those who did not have wheelchairs, most residents had to stand inevitably when using, which increased their physical burden. We also observed that a great portion of their social interactions took place when they were sitting at tables. Interactive public desktop displays could be a potential direction applied in caring environments.

– The field trial should include necessary introduction and explanations:

This study proved necessary introductions and explanations played an important role for the residents to understand and motivate them to use independently. Most of the participants who used OutLook admitted that they got to understand it from the introduction activity. However, only 22 residents participated in this activity although we sent 130 invitations. Furthermore, among those who joined the introduction session, many residents forgot most of our demonstrations and could not recall the whole idea afterwards. The main reason was that we only conducted this activity once and only lasted about 2 hours, which could not match many residents' schedules and daily routines. Besides, it usually took more time to attract the inactive residents to take part in new events than those active ones. Therefore, we suggest such activities are very necessary to introduce public technical applications in caring environments and should cover more residents, especially those inactive ones. To be specific, first of all, the time and duration could be extended to match more residents' schedules. Printed introductions could be sent to their mailboxes to attract

them to join and experience. Secondly, a semi-open pre-test session could be conducted for a week before open field trial. Designers or caregivers could provide continuous assistance in this session. Thirdly, during field trial, printed manuals with simple illustrations could also continuously guide them.

7. Limitations and future work

Limitations of this study are related to the sample of the study and the period of the intervention. Since the field trial was performed in an open space, to minimize Hawthorne Effect, the subjects were found after Intervention. It was difficult to get a complete sample of users. Due to some budget and maintenance requirements, each session of the observation lasted 1 week and the displays could not open for the whole day, which could be extended in the future work. Furthermore, based on the present results, some upgrades and new iterations can be done in the future to verify the factors proposed in discussion. For example, the following directions could be further explored: (1) the relationship between the locations of public displays in caring environments and their social effects. (2) How to balance between implicit and explicit of the interactive public displays to attract the residents without confusing them. (3) More innovative interfaces which are more tangible, inviting and natural for the nursing home residents is also a promising area.

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