ORIGINAL ARTICLE

INVITATION: An Elderly Friendly ICT-enabled Interactive Installation to Promote Social Participation

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Abstract: Many countries are facing significant challenges posed by aging populations, and many of these elderly people are increasingly socially isolated, raising the need to develop senior-friendly services and settings for community life. ICT-enabled technologies can be used to help the elderly maintain adequate degrees of social participation. This paper reports the design and production of an innovative recreation installation featuring elderly friendly technologies to enhance the social lives of elderly Chinese people. The contents are composed of modernized visualization elements of traditional Chinese painting designed to engage elderly Chinese people and promote interaction and participation.

Keywords: Smart Technology, elderly friendly, social participations, interactive experience

Introduction

From 2000 to 2050, the proportion of the world's population over the age of 60 will double from about 11% to 22% [1] and the number of people aged 80 or above will quadrupled to 395 million [2]. This continued increase in life expectancy raises challenges in maximizing the health and well-being of older people, as well as their social participation and security [3]. More older people are living alone, and social isolation amongst older people is emerging as one of the major issues facing the industrialized world because of the adverse impact it can have on health and wellbeing [4]. Inter-personal communication between elderly people has been identified as a critical key element for life adjustment, linking people to their environment [5].

Considerable research has been devoted to the social participation of elderly people. A technology training program for senior citizens - Older Adults Technology Service (OATS) - demonstrated the influence of both social environments and active community-based aging on older New Yorkers [6]. This program shows that Information and Communication Technology (ICT) has the potential to contribute to individual and community empowerment and capacity building, and can effectively address social exclusion among older adults. As for physical health, the Socially Assistive Robot (SAR) system was designed to help elderly users engage in physical exercise to improve health and quality of life [7]. Another initiative, named PARO, created a baby seal as the friendly user interface of a socially assistive robot. Experimental results showed that PARO had both direct (through interacting with PARO) and indirect effects (through engagement with other people and the environment) on the activity levels of older adults suffering from cognitive impairment [8].

Extending the research focus from object-wise tools to an environmental installation, an innovative recreation installation for elderly people was proposed [9] to encourage the elderly lead more active social lives, especially those residing in specialized communities, such as Continuing Care Retirement Communities (CCRCs), or Fee-for-Service Continuing Care Retirement Communities (FFSCCRCs). As defined by the New York Department of Health [10], such facilities allow residents to lead independent lives, while having access to a continuum of

long-term care services as their health and social needs change over time. This paper proposes a revised design and implementation to appeal to Chinese elderly with modernized visualization elements of traditional Chinese painting.

In the following sections, we review the literature on reducing social isolation and promoting social participation for senior citizens, and present the design of the proposed system. Finally, we conclude this paper with a summary of the key research contributions.

Related Literatures

Age-friendly Technologies

Recently, increased attention has focused on developing age-friendly services and settings in all aspects of community life [6] to support age-friendly environments and to help older people live fuller lives. Creating age-friendly physical and social environments can have a big impact on improving the active participation and independence of older people [3].

Assistive Technologies (AT) allow individuals to independently and safely perform tasks that they would otherwise be unable to do [11], and elderly users have been found to be accepting of straightforward, reliable and need-specific AT [12].

ICT-enabled Technologies for Active Ageing

ICT technology has been integrated into assistive technologies in various applications, including a human-robot interaction proposed to socially motivate physical exercise for older adults [7]. The results showed a strong participant preference for the relational robot over the non-relational robot in terms of enjoyment and companionship value. Results also demonstrated similar the robot provided useful interaction and social presence.

Results from another study on ICT training programs suggest that comprehensive ongoing engagement and re-engagement can help older adults build, maintain and restore their social connections within their various communities [6]. The same study proclaimed social and civic participation can improve physical and mental health, cognition, and emotional well-being among older adults.

Another robot, named PARO, was used in multi-sensory behavioral therapy in a nursing home setting [8]. Using a baby seal as its user interface, PARO provides indirect benefits for users by increasing their activity in particular modalities of social interaction, including visual, verbal, and physical interaction with primary and non-primary interlocutors.

In the context of ICT–enabled interaction design, researchers have suggested that intuitive interfaces should be developed based on users' earlier encounters with similar experiences or environments [13-17]. In other words, intuitive interfaces can reduce technology anxiety by reducing time and effort needed for interaction and largely eliminating the need for conscious reasoning [17]. These findings were supported by Ortiz et al. [18] in their proposed interaction design model of a viewer-content feedback loop for bio-signal driven interactive art.

Design Methods

The proposed elderly friendly ICT-enabled interactive installation is called "Seasons' Wholeness" to connote emotional equilibrium, and the installation experience follows the research design of the INVITATION series [9]. The User Experience (UX) design team from Industrial Technology Research Institute (ITRI) designed the heptagonal space using subtle and translucent materials, such as gauze, needlework, and wooden frames, tangible elements familiar to Chinese elderly people, thus helping to reduce their anxiety toward contemporary technologies. This section provides a detailed description of how the user experiences and interacts with the technology.

Sensing Technology

The "Seasons' Wholeness" environment consists of a pair of upholstered chairs in which the users sit and chat. Unlike previous INVITATION series [9], which captured user bio-signals using a Nanosecond Pulse Near-field Sensing (NPNS) wrist band, this edition mounted a non-contacting physiological sensor Ultra Wide Band (UWB) inside one of the chairs, as illustrated in Fig. 1.

The sensor can detect human breathing and pulse signals [19]. It emits a pulse electromagnetic waves with very broad bandwidth in frequency domain used to detect physiological signals. The antenna receives the reflective UWB wave from the surface of the user's body or

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cardiovascular system, and the received signal is used to calculate respiration and pulse rates. Using the UWB sensor frees the user from having to wear any specialized equipment, thus enhancing willingness to use.

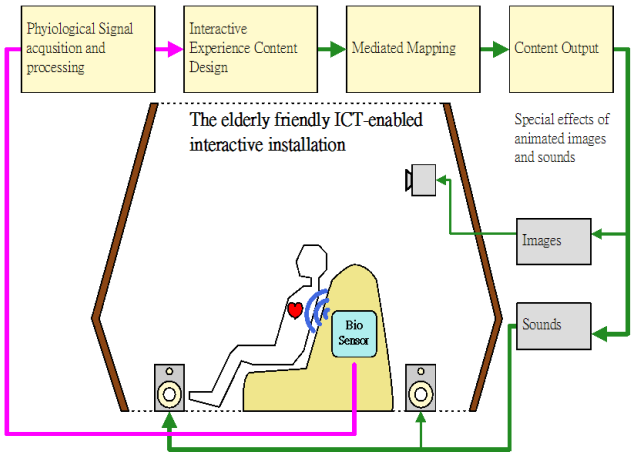

Figure 1. "Seasons' Wholeness" Interactive Experience Design

Physiological Signal Processing

Heart signal detection technology is commonly used to evaluate human emotional states through calculating heart rate (HR) and heart rate variability (HRV), which measures the naturally occurring beat-to-beat changes in heart rate. These heart rate parameters have been extensively investigated and affective indexes have been developed to validate relations between the parameters and the user's emotional state. The most widely used methods include time-domain and frequency-domain data analysis. Based on frequency analysis, power spectral density (PSD) is used to provide basic information on the power distribution across frequencies using discrete Fourier transform. The power information in different frequency ranges for affective analysis is commonly separated into High Frequency (HF), 0.15-0.4Hz, and Low Frequency (LF), 0.05-0.15Hz. For example, High-frequency activity has been shown to decrease under conditions of acute time pressure, emotional strain [20] and elevated anxiety, presumably related to focused attention and motor inhibition. Figure 2 presents a flowchart of related data analysis processes.

Timeline of the Whole Experience

Once relaxed in the chairs, the users begin a "Seasons' Wholeness" interactive session which lasts about 19 minutes. While two people sit in the chairs at the same time, bio-signals are only acquired from one participant at a time. As shown in Fig. 3, the process includes a preparation stage, three sequential intervention stages, and an ending stage.

In the preparation stage, the UWB monitors and acquires the subject's arterial pulse for about 5 minutes. The ICT-enabled system then processes the mediated mapping of bio-signals into sounds and images. The preparation stage should be long enough for the subject to engage with the environmental design but not so long as to test his/her patience. The subsequent interventions are designed in 3-minute intervals and repeated 3 times each.

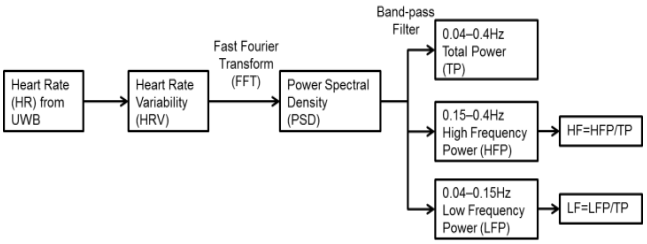

Figure 2. Physiological signal processing flow

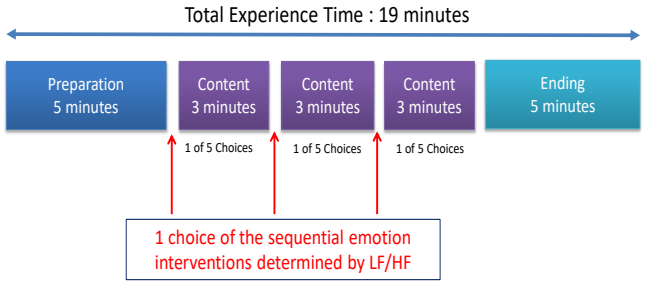

Figure 3. Timeline of "Seasons' Wholeness" Interactive Experience

Interactive Experience Content Design

The ITRI UX research team assigned 5 Autonomic Nerve System levels to 5 segments of LF/HF balance coefficients. The system corresponds to the status of each Autonomic Nerve System (ANS) level. The mapping instantly captures the status of the ANS, which is then matched to one of five conditions of emotional interventions. The design settings chart is shown in Figure 4. While the ANS level is in the normal state (LF:HF=5:5), the theme of "Season's Harmony" plays. Other conditions correspond to other themes: Hyper state (LF:HF=9:1~8:2) corresponds to the theme of "Immersive in Winter," high state (LF:HF=7:3~6:4) corresponds to the theme of "Revive in Spring," low state (LF:HF=4:6~3:7) corresponds to the theme of "Adorn in Autumn," and very low state (LF:HF=2:8~1:9) corresponds to the theme of "Flourish in Summer." The color and sound schemes were developed in accordance with each season's key shades.

Mediated Mapping

The ITRI UX research team assumed that the balance between the sympathetic and parasympathetic ANS was better for elderly people both psychologically and physiologically. Thus the five themes of emotional interventions help participants achieve emotional balance. Each of the five emotional interventions corresponds to

an exhibition of composed images and sounds according to the bio-signals received. This type of intervention follows the idea of "mediated mapping" within the model of viewer versus content feedback loop (Fig. 5) as defined in Ortiz et al's research into bio-signal driven art [18]. As compared to "directed mapping", where interactive images and sounds reflect or reveal what the subject's HRV state, "mediated mapping" aims to allow an intervention to better stimulate the subject's HF and LF to reach the balanced norm.

Experience Design Setting according to Balance Coefficient of Autonomic Nerve System

Balance Coefficient of Autonomic Nerve System (LF/HF)	Theme and Style	Content Output : Images [color Scheme]	Content Output : Sounds [quasi heart-beat effects]
Hyper Hyper active Sympathetic nervous system LF/HF=9:1~8:2	冬藏 **Immerse in Winter** Soothing with a flair of movement, nurturing	blue as basis, grey purple for the flow, pink for the rich fragrant	Recurrent repetition Long-note sound design [3 counts of RRI merged as 1, achieving a rhythmic pattern of prolong effects]
High Active Sympathetic nervous system LF/HF=7:3~6:4	春萌生 **Revive in Spring** Awakening on earth, reviving in life	spring green, blue purple	Relaxed music style [2 counts of RRI merged as 1, achieving a rhythmic pattern of easy mood]
Normal autonomic nerve system LF/HF=5:5	四季 **Season's Harmony** Moderately blending ~	neutral, green, purple	Upholding personal rendezvous with quasi heart-beats [steady beats progressing , creating a sense of companion]
Low Active Parasympathetic nerve system LF/HF=4:6~3:7	秋點粧 **Adorn in Autumn** Like painting, adorned with poetry	orange, yellow, brown	A rhythmic guidance into stimulation [Single RRI divided, achieving a short-note rhythmic pattern of awakening mood]
Very Low Hyper active Parasympathetic nerve system LF/HF=2:8~1:9	夏蕃蕪 **Flourish in Summer** Energetic colors of blossoms intertwining	red, pink	Lively attractive tone Moving ambience [Single RRI divided, achieving a dotted /irregular rhythmic pattern of vivid allegretto effects]

Figure 4. "Seasons' Wholeness" Interactive Experience Design

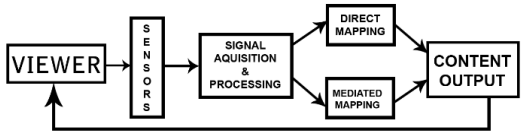

Figure 5. Viewer ←→ Content Feedback Loop (Ortiz et al., 2011)

Installation Design

The content output of the "Seasons' Wholeness" Interactive Experience takes the form of images and sounds. Bio-signals obtained from the subject are used to create real-time interactive images related to the concept of mist originating from traditional Chinese brush painting. Presented in a series of chiffon silhouettes, the floating pathway of mist is artistically projected onto one of the installation's gauze screens, as illustrated in Fig. 6. The five bio-signal driven images are each complemented by a corresponding pre-composed piano piece.

Social participations

Since the gauze screen is translucent, the real-time bio-signal driven images can be observed both from the inside and outside of the structure, allowing both the pair of participants within the structure and their friends gathered outside to simultaneously appreciate the silhouette artwork, as shown in Figure 7.

Figure 6. Images projected on the gauze screen

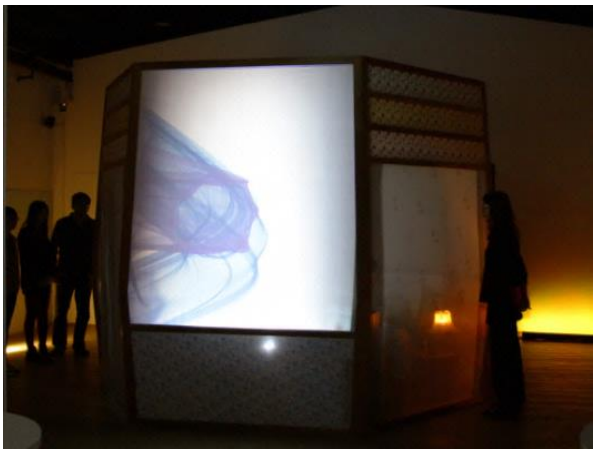

Figure 7. Social participation outside the "Seasons' Wholeness" Interactive Experience

Souvenir gift card for promoting social involvement

At the end of the interactive session, the bio-signal contributor receives a card featuring a still image created by his/her own physiological signals, as illustrated in Fig. 8.

This concept of an artistic souvenir card pays homage to the Swiss Freudian psychiatrist and psychoanalyst Hermann Rorschach, who was best known for developing the Rorschach inkblot test [21]. Combining Rorschach's interest both in art and psychoanalysis, his personality projection test was designed to reflect an individual's unconscious while describing the images they perceived in a series of inkblots. As a result, individual personality was reportedly "projected" onto the stimuli.

A similar process of self-exploration and quasi personality decoding seems to result from interaction with the Chinese mist paintings in "Seasons' Wholeness". On the one hand, the projection of one's inner nature appears to be rather direct and intensively personal, especially with the aid of bio-signals. Yet, on the other hand, the artistic rendition of bio-signals demonstrates indirect and ambiguous meanings, which can only be read,

understood, and explained by each individual.

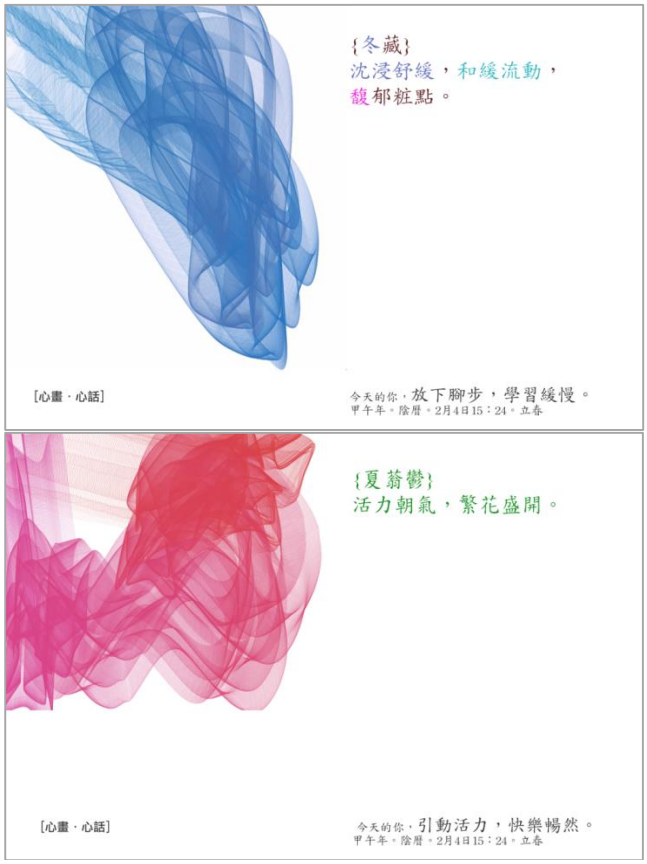

Figure 8. Printed artistic souvenir cards of "Dialogues of Heart" & "Paintings of Heart"

Participants are greeted with the encouragement that "everyone can create an artwork with his beating heart", motivating them to partake in more intuitive and frequent social involvement. The artistic souvenir card, provides the participant with an opportunity to engage in personal expression and also to initiate interpersonal communication with others. Such communication is a critical aspect of life adjustment, linking people to their environment [5]. The souvenir card serves as a stimulus for conversation which can then encourage other participants to engage in emotional bonding.

In addition to the artistic image, two written messages are printed on the souvenir card. The top text takes the form of a modern Chinese poem to illustrate the color scheme and the experience of the corresponding Season. The artistic and poetic touch of the top text was developed for the residents of the test CCRC, who are well-educated and interested in Chinese culture. The bottom text provides an encouraging message which echoes the emotional feeling of the bio-signal contributor.

Experimental method and results

A pilot experiment was designed to evaluate the effectiveness of the installation design. This first attempt focuses on the user's appreciation of and reaction to the accompanying piano music. A total of subjects aged from 45 to 60 participated in the experiment. The subjects were asked to sit in the installation chair and rank each piano piece according to preference with a set of prepared cards after listening. The cards replace the traditional pen and paper questionnaire and provide an intuitive method to rank emotional response. In addition, the recorded scores of the cards easily follow the Latin Square experiment design method. The detailed text and meaning of each card is listed in the "Theme and Style" column in Figure 4. Then the staff records the ranking. Preference results are shown in Table 1.

Music / Feel	Winter	Autumn	Summer	Spring	Four Season
Season's Harmony	3	3.3	2.7	3.8	3.9
Revive in Spring	2.7	2.8	3.7	3.1	3.6
Flourish in Summer	1.1	1.4	4.7	2.7	1.9
Adorn in Autumn	4.1	3.5	2	2.1	2.1
Immerse in Winter	4.1	4	1.9	3.3	3.5

Table 1. Mean preference scores for the five music pieces

Results showing the highest mean scores in the grey boxes closely correspond to the corresponding season, with the exception of Autumn and Spring. Some participants identified the Autumn music as sharing same the characteristics of Winter, while the characteristics of the Spring music could not be identified clearly.

This preliminary experiment tries to determine how music affects the installation audience. Other elements, such as images and lighting, serve as ambient factors. When combined with music, these elements construct a recreational environment to promote active social interaction among elderly participants.

Conclusion

An elderly friendly ICT-enabled interactive installation, titled INVITATION, is designed to promote social participation among elderly people. The installation features tangible and aesthetic elements which are designed to appeal to Chinese elderly people. Non-contact physiological UWB sensors are used to obtain bio-signals from participants without the need for users to wear special devices and thus encouraging stress-free participation. Both the image content and the sound content are related to Chinese art and philosophy, and are designed to engage the user's sense of aesthetics. At the end of the installation session, users are presented with a souvenir cards to share with others and encourage social involvement. Future implementation and research can be

conducted in CCRC environments to further validate this approach to improving social participation among elderly people.

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