Designing to Support Social Connectedness: *The Case of SnowGlobe*

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Social awareness systems aim at supporting social connectedness by providing users with subtle cues about what is happening in their social network. In developing such systems, designers are faced with many design choices that influence the way social connectedness is affected. Typically, the designs and evaluations of social awareness systems lack foundations in formal models of social connectedness. This paper first describes a conceptual model of social connectedness, which provides a guideline for the design and evaluation of a social awareness system called SnowGlobe. SnowGlobe is a lamp that creates interpersonal awareness of movement between people in two remote living rooms. It displays movement of a remote user by glowing brighter, and users can exchange *nudges* by users shaking their SnowGlobes, making the remote SnowGlobe blink. The user-system interactions and the effect of system use on social connectedness were evaluated in a field trial. Participants used a SnowGlobe for several weeks and experienced SnowGlobe as a complementary form of communication. Interviews and log-data show that participants enjoyed using SnowGlobe, and that it contributed to relationship saliency and closeness as dimensions of social connectedness. Key design aspects for this effect were found to be the low-bandwidth level of communication, the ambiguity of the interaction, and the physicality of the interactions.

Keywords **–** Awareness Systems, Social Connectedness, Tangible Interaction, Field Trial.

Relevance to Design Practice **–** This paper describes the integration of a theoretical definition of social connectedness into the design and evaluation of a social awareness system.

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Introduction

In recent years, an interesting class of communication systems has emerged: Social Awareness (SA) Systems. These systems aim at increasing people's sense of social connectedness by providing them with peripheral awareness of information about people from their social network (e.g. presence, availability, activities). The interaction principles of these systems are based on the paradigms of *Ubiquitous Computing* (Weiser, 1991) and, more recently, *Ambient Intelligence* (Aarts & Marzano, 2003). These paradigms envision electronic devices woven into the fabric of our daily life and activities, smoothly moving back and forth between background and foreground of the users' attention. Therefore, SA-systems are complementary to more traditional communication technologies and services, e-mail or social networking services, which demand dedicated user attention and engagement.

In general, SA-systems are considered to support people's social well-being by stimulating their sense of social connectedness. A review of the existing work in this domain, such as Presence Lamp (Pedersen & Sokoler, 1997), GustBowl (Keller, van der Hoog, & Stappers, 2004), and the ASTRA project (Romero et al., 2007), shows that formal evaluation of social connectedness is complex, and designers and researchers are not always successful in determining the effects of their designs. The goal of the present study is to create a deeper understanding of how design and interaction features of an SA-system affect social connectedness. In the present study, a theoretical understanding of social connectedness is used to ground the design decisions and to structure the evaluation.

In this study, we use the definition for social connectedness as described by van Bel, IJsselsteijn, and de Kort (2008): *The momentary affective experience of belonging to a social relationship or network*. Social connectedness can be the outcome of subtle events in one's peripheral area of attention, or it may be caused by explicit acts, such as by making a phone call or visiting a friend. The construct is described by five dimensions which can be used to inform the design and evaluation process of an SA-system.

Based on this conceptual understanding of social connectedness, an SA-system called SnowGlobe was designed. The system supports interpersonal awareness by communicating each other's movement in their living rooms. It also enables users to actively nudge each other; when shaking one SnowGlobe,

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the remote device will blink shortly. Through a longitudinal field study, we investigated the effect of user interactions with the system on the dimensions of social connectedness. These dimensions were also the basis for the measurement instruments used in the evaluation. Overall, using SnowGlobe was found to have a positive effect on social connectedness by contributing to the dimensions *relationship salience* and *closeness*.

This paper provides an overview of the related work in the field of SA-systems, followed by a description of the social connectedness dimensions that were used for the design of SnowGlobe. This is followed by a description of the iterative design process of SnowGlobe, and evaluation methods applied are outlined. Accordingly, the findings from the field study are provided in terms of system use and effects on social connectedness. Finally, we discuss the approach taken for measuring social connectedness, and we provide design insights and suggestions for the design of future SA-systems.

Related Work on Social Awareness Systems

The pioneering examples of SA-systems were targeted at work environments, and they have their roots mainly in the domain of Computer Supported Collaborative Work (CSCW). The research into these systems co-emerged with Weiser's vision on *calm technology* (Weiser, 1991). Key projects are Portholes (Dourish & Bly, 1992) and Media Spaces (Bly, Harrison, & Irwin, 1993), which both create awareness of the activities of colleagues in different workplaces by a video communication link. These studies were followed by several other projects that used peripheral awareness of colleagues to increase work efficiency (e.g. Pedersen & Sokoler, 1997).

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Blending Social Awareness in our Daily Lives

In line with the more recent vision of Aarts and Marzano (2003) on ambient technology, researchers have shown an emerging interest in awareness systems for the home and leisure context. In a first category of approaches to SA-systems, designers and researchers focused on the innovative and conceptual qualities of the design, while emphasis on the empirical evaluation of the designs was less profound. For example, Strong and Gaver (1996) designed and built the Feather prototype, which manifests their vision on *provocative awareness* (Gaver, 2002). The prototype is a small portable box which can be opened to see a picture of a loved one. Opening the box triggers a feather to drop down in a glass tube that is situated in the living room of the loved one. Another example is the Lampshade mock-up that was built as part of the Casablanca project (Hindus, Mainwaring, Leduc, Hagström, & Bayley, 2001). The design enabled users to indicate their home presence to someone else by turning on a lamp, triggering the presence lamp of the remote user to glow. In both cases the prototypes were presented as proof of concepts only; the effect of the prototypes on user experience was not studied.

The GustBowl (Keller et al., 2004) was developed to improve the communication between students and their parents. Whenever the student places a small personal object in a bowl, it is photographed and displayed in the parents' bowl, giving him or her a peek into the life the son or daughter. These designs followed an artistic (Feather) or a metaphorical (Lampshade and GustBowl) approach to designing an awareness system. Vetere et al. (2005) performed a study into users' wishes and needs with respect to SA-systems. They identified ways to mediate intimacy between people, using modern technology. Key concepts include the physicality of interaction and closeness to the body. These were demonstrated in a prototype called Hug-over-a-Distance, enabling people to exchange physical movement (e.g., patting and hugging) over a distance using force sensors and vibration motors. With respect to the tangible nature of these devices Rittenbruch and McEwan (2009) suggest that tangible interactive objects, opposed to screen-based displays as the basis of SA-systems, may be more effective in a home context as they are considered by users to be more intimate, simple, emotionally meaningful and aesthetically pleasing.

Evaluation and Measurement

The projects discussed in the previous section aimed at awareness systems blending into the daily lives of users. However, little effort was made to deeply evaluate the effects of the designs in terms of user experience. The Digital Family Portrait (DFP) (Mynatt, Rowan, Jacobs, & Craighill, 2001) project has become a classic example of how empirical in-situ evaluation can be done as part of the development of an SA-system. DFP is a system that shows information about the location and activity of a senior to the son or daughter on a digital photo frame. DFP aims for an increase in peace of mind. Through a pilot study in a lab environment, the researchers recognized the need for a longitudinal study in the user context (Rowan & Mynatt, 2005). In the field study, users informally reported increased feelings of being connected, even though DFP is based on one-way monitoring rather than interpersonal awareness.

Kaye (2006) developed the Virtual Intimate Object (VIO), which is a small button in the Windows OS taskbar that connects two distant PC users. A user can click the VIO, making the VIO on the other person's PC turn red, which fades over time. In this way, users can indicate that they are thinking of each other. By asking open-ended questions and collecting qualitative data, Kaye found that VIO stimulates closeness in some cases. Dey and Guzman (2006) evaluated the effect of an awareness display on social connectedness between distant loved ones. The display was positioned next to the personal computer of a user and showed the online/offline status of his or her loved one. This display was evaluated in context for three weeks. Increased feelings of "being in touch" were reported in the study.

As a final example, the ASTRA project (Romero et al., 2007) studied a service which allowed family members to send images and text from their mobile phone to a screen situated in the family home. The system was evaluated both in a laboratory and in the real homes of two families. During the experimental trials, ASTRA was perceived positively in terms of the affective benefits, which was determined through using the ABC-questionnaire (IJsselsteijn, van Baren, Markopoulos, Romero, & de Ruyter, 2009) for pre- and post-intervention measurements. The ABC scale weighs the perceived costs (i.e., effort and privacy) against the benefits (i.e., increased interaction and intimacy) to grasp how an intervention affects the users' social benefit. Using this scale, the researchers were able to find the affective benefits of the designed system, but they could not identify the effects of particular interactions on social experiences.

The studies above describe how screen-driven awareness displays can be used to increase social awareness. However, the studies have drawbacks in terms of integrating design and evaluation activities. Although user studies were conducted in many of the studies outlined above, there appears to be a lack of common qualitative and quantitative measures that would enable the comparison of findings and the further development of SA-systems. They are generally only loosely grounded in theory on social connectedness, leading to inconsistency between design goals, designed interactions and evaluation criteria.

Study Procedure

To gain deeper understanding on how the use and functionalities of an SA-system affect social connectedness, the following steps were defined for the current study.

1. **Develop theoretical understanding of social connectedness.** An understanding of the underlying theories is considered essential, as it enables identification of design decisions that optimally support social connectedness.
2. **Design and prototyping of a social awareness system.** Following the Empirical Research Through Design Method (Keyson & Bruns Alonso, 2009), several prototypes will be built to understand interaction qualities. A final prototype will be built, integrating knowledge gained from theory and the design iterations.
3. **Field evaluation.** A longitudinal field evaluation will be performed. Evaluation criteria are based on the conceptual definition of social connectedness.

A View on Well-Being and Social Connectedness

For several decades, researchers in psychology and social sciences have found that the social aspects of life contribute significantly to an overall sense of well-being. Half a century ago, Maslow (1968) suggested that love and a sense of belonging are important contributors to well-being. Since then, an extensive body of more recent work underlines the effects of social well-being on overall well-being and physical health (Baumeister & Leary, 1995). Social well-being is determined by belongingness, as well as by concepts that are less related to direct social interaction, such as *social status* and *behavioral confirmation* (Ormel, Lindenberg, Steverink, & Vonkorff, 1997).

To understand the potential of SA-systems in supporting social well-being, a more detailed construct is needed to account for several aspects particular to the domain of social interaction. To illustrate the subtleness of awareness in the context of social interaction, one could consider the following encounter:

> Kevin walks his dog around the block every morning at the same time. Today, as he passes his friend Mike's house, he sees Mike's green Toyota still parked in front of the door. "He's usually off to work at this time…" he thinks, realizing that Mike must have an extra day off today. "That's good for him; he's been super tired after having to meet those deadlines last week. Hope he enjoys it." As he walks the dog back home he passes his neighbour and exchanges a short 'hi' with him. Although he doesn't really talk to him very often, it's good to know they're still in touch.

In the encounter described above, Kevin experiences several subtle social stimuli, which each temporarily affect Kevin's feeling about the relationship with two different people. In the first case (Mike's car), no intentional communication is involved, and in the second case (neighbor) there is very subtle interaction with another person. SA-systems are particularly suitable for these types of interactions. The story indicates three important aspects for discussing the value of an SA-system: 1) the momentary effect of the interactions, 2) the subtleness of the interactions, and 3) the interpersonal relationship. The concept of social connectedness, as detailed below, includes these three dimensions.

Social Connectedness is described as the momentary affective experience of belonging (Rettie, 2003). The concept is described by Van Bel et al. (2008) along five dimensions, ranging from subtle experiences to experiences that are more likely to be the outcome of richer interactions:

1. *Relationship saliency* – The prominence of the relationship in ones mind, which is the outcome of thinking of another person or being aware of him/her.
2. *Closeness* – The experience of feeling close to another. This does not relate to physical proximity, but rather to the social presence in ones mind.
3. *Contact quality* – The perceived quality of social contact with another person.
4. *Knowing each others' experiences* – being aware of each others experience, both in terms of subjective experiences (e.g. love, enjoyment, sadness), as well as awareness of things that happen in ones life.
5. *Shared understanding* – having a similar view on the world. Having similar opinions and being on the same wavelength.

The inclusion of dimensions that may be affected by subtle experiences and interactions (*relationship saliency* and *closeness* in particular) in a relationship make the concept particularly suitable for informing the design process of SA-systems.

Social connectedness is strongly related, but different from other frequently used higher-level concepts such as *belongingness* and *loneliness*, which each describe a longer-term affective state, which is not easily changed by a single social interaction (Reis & Patrick, 1996). In other words, a prolonged increased sense of social connectedness will support belongingness and, in the long run, social well-being. When using these constructs, it becomes more challenging to describe the effects of SA-systems. Also, similar to *relatedness* and *intimacy*, belongingness and loneliness evaluate one's overall experience, accounting for ones complete social network and stimuli, whereas social connectedness is usually concerned with a particular one-on-one relationship.

Methods relating to the measurement of social connectedness rely primarily on interviews or self-report scales. The Interpersonal Connectedness Questionnaire (IC-Q) was developed as a self-report measure for the construct (van Bel, Smolders, IJsselsteijn, & de Kort, 2009). The questionnaire particularly targets short-term experiences through the design of the items. Although originally developed in a lab context, Khan and Markopoulos (2009) have also used it in a field context.

Implications for Design

The definition of social connectedness can be used to help guide the design of SA-systems. When building these systems, designers should aim for outcomes in terms of increasing one or more of the dimensions of social connectedness. This would enable them to make informed decisions in design iterations, thereby efficiently improving the designs. The dimensions that relate to subtle interactions and experiences (*relationship salience* and *closeness*) are most likely to be targeted by SA-systems. The dimensions also provide a framework for formal evaluation of the designed interactions.

The Design of SnowGlobe

The design process of SnowGlobe can roughly be described in three phases: a design exploration, the design of a final prototype for the field trial, and the technical implementation. The goal for the field trial was to build an awareness system that (1) increases social connectedness for senior users, (2) could be built with the resources available and that (3) would be sufficiently robust and reliable to be placed in the field for an extended period of time.

Design Explorations

Three design teams, each consisting of four postgraduate students from a design course (on using interactive technology in design) in our institute, conducted the first design explorations. They were instructed to design an SA-system that supports social connectedness between them and their grandparents. They were to consider tangible interaction solutions, rather than screen based designs, and to aim for solutions that were interwoven into the daily lives of people. Also, the students were asked to focus on supporting relationship saliency and feelings of closeness, rather than the sharing of richer content. The students evaluated their prototypes with users in an exhibition, where about 40-50 people provided feedback (10-20 of age above 60).

Design Exploration 1: WeDo

One design team focused on interpersonal awareness of movement. The team explored various ways for communicating the amount of motion in a room, between living rooms. The team used a passive infrared (PIR) sensor to measure the movement. The sensor was co-located with the display device to enable users to decide and understand what part of their living room space would be monitored.

The end result, called *WeDo*, consists of two boxes (Figure 1) that are placed in the living rooms of the grandparents and grandchild respectively. When the grandparents' box detects motion in their room, the grandchild's box displays light through a crack in the opening, indicating that something is going on; the more movement, the more light is displayed. When opening the box, the grandchild can see more about the intensity of the

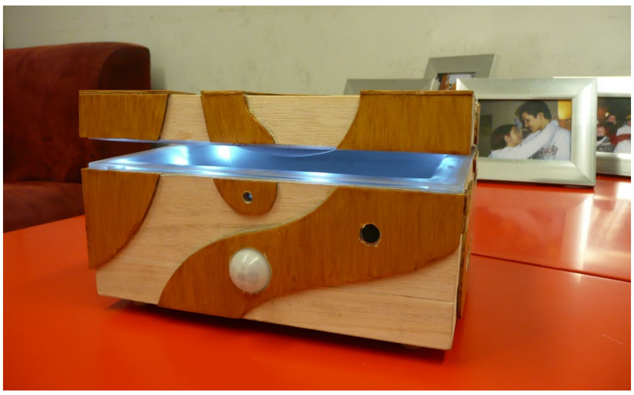

Figure 1. The WeDo prototype includes a motion sensor and a light.

movement (by softly or violently moving Styrofoam balls) as well as hear snippets of sounds from the grandparents' living room.

The evaluation indicated that users understood the concept and display, and they particularly liked the separation of the background information (light in the small opening) and the foreground information (opening the box). Users also expressed they experienced the live and analogous display of presence through the small opening, and the intimacy of the design as stimulating in the sense of "*...as if (s)he is here with me*." This notion relates strongly to the sense of closeness. Users did not explicitly mention a more salient relationship, but they did indicate that they would probably think more of their grandparent/child when having the device.

Design Exploration 2: KeyPing

The second team closely linked the interaction to the ritual habits when returning home (similar to Keller et al., 2004). When coming home and closing the door behind them, many people put their keys in a fixed place. The design team built their awareness system around this ritual.

The design, called *KeyPing*, is an interactive board that has several tokens attached (Figure 2). The tokens are magnetic and movable, each representing one of the relatives of the user. By hanging his keys on the board when coming home, a grandparent activates the board. By doing this, the presence is communicated to the other relatives. At the same time on the board of a grandchild, the token representing the grandparent will light up. As a more active means of communication, a grandson, for example, can *nudge* his grandparent by clicking the token to make the token representing him light up brightly on his grandparents' board. Users particularly appreciated the *nudge* functionality as an opportunity to communicate actively. Nudging stimulated their awareness of the relationship, by making them think of the other when sending or receiving a *nudge*.

Figure 2. The KeyPing prototype consists of a board with keys and personalized tokens.

Design Exploration 3: Cocoon

The third team focused on using audio to indicate when the grandparent would be in the same room as the grandchild. For example, when the grandson was making dinner in his kitchen, and the grandmother would enter her own kitchen to get something to drink, she could hear a particular sound that could be associated with her grandchild.

The awareness of co-location is a novel concept compared to existing work, but the team found that users had problems understanding the concept. The absence of a visible product, and the intangibility of audio seemed to constrain understanding.

Design Reflections

Through the design of WeDo, we learned that simple light cues could serve as ambient notifications, supporting a sense of closeness in the periphery of ones attention. The KeyPing exploration contributed to the notion of a *nudge* function, which enables a user to express intentional communication, bringing the system from the periphery to the foreground of ones attention. Prospective users perceived *nudging* as a powerful communicative message, even though it had no content other than a blinking light. They noted that the nudge function increased their awareness of the relationship by making them think actively of the other. From Cocoon, we learned that the absence of a visible display hinders the user in understanding the stimuli provided by the system.

SnowGlobe Design

In preparing a field study, we focused on a house-to-house SA-system for sake of simplicity of the setup. In this way, we would be able to investigate the effects of the system with a limited number of prototypes, without having to involve several larger social groups. For this final prototype, we adopted the most salient principles found through the design explorations, listed in Table 1.

During a brainstorming session following the design explorations, a snow globe was coined as a metaphor for the awareness system to visualize the tangible, physical and visual qualities of a real snow globe. SnowGlobe was designed as an SA-system that blends into the living room interior as a lamp (Figure 3). It embeds the system features in Table 1 in the

Table 1. System features.

System feature	Envisioned outcome
1) Abstract display of movement as background communication	• Supports awareness of the other (relationship saliency) • Supports feelings of social presence (closeness)
2) Nudging as foreground communication	• Supports "thinking of the other" (relationship saliency) • Enables explicit intentional communication
3) Co-located sensor/display	• Simplifies field installation • More comprehensible for users

following ways: (1) It displays the amount of activity in the living room of another person by the amount of purple light and snow that is fluttering around in the globe; (2) One can *nudge* the other person by shaking one's globe, which will cause the other person's SnowGlobe to light up brightly in orange for ten seconds, and the snow flakes to move around noticeably; (3) In the current versions, the sensitivity of the sensor and the colors related to the two functions are fixed, based on what the designers and several consulted end users found both aesthetically pleasing and distinctive. As Figure 4 shows, all sensors and display are contained in one device.

To provide users with a sense of privacy control, users can cover the SnowGlobe with a cloth to prevent the SnowGlobe from displaying and detecting any movement. To see what is going on in the living room of the relative, users have to remove the cloth and thus have to expose themselves as well. This mechanism has an advantage over an on/off switch in that it is less likely that users forget to turn the system on again (a cover clearly indicates the status).

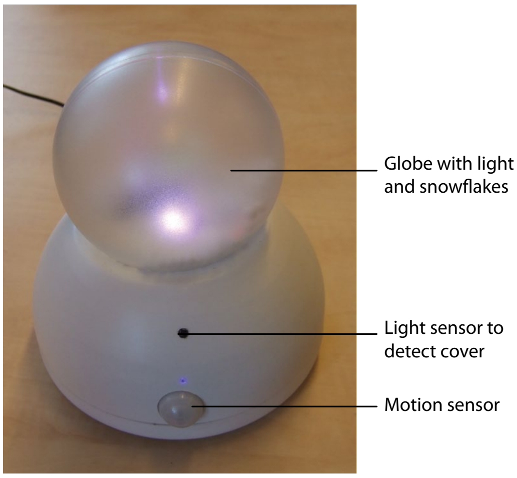

Figure 3. The SnowGlobe prototype includes sensors and a display.

Technical Implementation

In the implementation phase, three issues were considered essential to enable an uninterrupted product experience in the field: robustness of technology, physical robustness and flexibility. To secure technological reliability, the prototype should be pilot tested in a real user home and system, and errors should be easily solved during trials. Also, the researchers should be able to monitor the status of the prototype and the communication at any time. The prototype should be physically robust as it will be subject to daily use; having to make repairs during trials is not desirable. Finally, the prototype and the additional hardware should be flexible; it should work in different homes, rooms and floors, without adapting the hardware and software. The paper by Visser, Vastenburg and Keyson (2010) provides a detailed outline on what measures were taken to ensure robustness, reliability and flexibility in this field setup.

As shown in Figure 3, SnowGlobe has a passive infrared motion sensor built in to measure the amount of activity at an angle of 135˚ within a range of ±7m from the sensor. Table 2 provides an approximate amount of movement and the display of light in the remote SnowGlobe that is linked to this. A tilt sensor detects when users shake the globe (*nudge* is sent when shaken for more than two seconds). A light sensor detects whether or not SnowGlobe is covered by a cloth. The globe is lit by an RGB LED and, ±100 small Styrofoam balls simulate the snow by being blown around by four small fans.

Table 2. Overview of activity types and light display.

Example activity type in living room 1	Brightness of SnowGlobe in living room 2
Empty room	0 % [a]
Reading newspaper / watching TV	25%
Eating breakfast or lunch	50% [b]
Walking by SnowGlobe at 2m – 5m distance	75%
Waving or walking close to SnowGlobe	100%

Note: [a] See Figure 8 for an impression. [b] See Figure 4 for an impression.

A schematic overview of the SnowGlobe field setup is shown in Figure 4. SnowGlobe is connected to a power socket, and a wireless ZigBee connection enables communication with an Apple Mac Mini computer. The computer provides the Internet connection that is needed to communicate with another SnowGlobe. When starting up, SnowGlobe connects to a server located at the authors' institute. The server then activates the Internet link to the other SnowGlobe. This setup allows the researchers to remotely check the system status at any time. Whenever the connection breaks down, the Mac Mini computer automatically attempts to reconnect every 30 seconds. As prototype technology often suffers from instability problems despite thorough testing, we built in a hard-reset function that enables users to restart their SnowGlobe by disconnecting and reconnecting the power to the computer. The prototype and the setup were deployed in a pilot setup with two users for 15 days to test the hardware and software in a live setting.

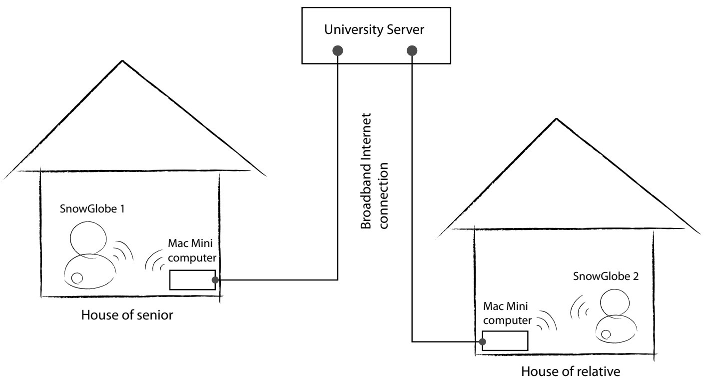

Figure 4. Schematic overview of the SnowGlobe field deployment.

SnowGlobe Field Trial

The evaluation aimed to gain insight into the effects of SnowGlobe on two levels.

1. **Effect of use on social connectedness.** We were interested in how social connectedness was affected by system use. In particular, we aimed at understanding how particular events of interactions affected the dimensions of social connectedness.
2. **Use and adoption of SnowGlobe.** We were interested in how the product would be used in a home environment. Also, we aimed at understanding the meaning users attribute to the interactions and display.

Additionally, we wanted to grasp how the system was appreciated in terms of interaction, usability, and clarity. The evaluation concerned senior users and one of their close relatives in their own home environment. Users lived their normal daily life whilst participating in the longitudinal field trial.

Measurement Instruments

To gain insight into the effects of SnowGlobe on social connectedness, 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 subjects (Patton, 2002). The interview guide included the following primary topics:

1. *Overall experience* (positive/negative experiences, the role of the product in daily life)
2. *Social connectedness* (including the dimensions relationship saliency, closeness, contact quality, knowing experiences, and shared understanding)
3. *Interactions and behavior* (response to display, attributed meaning of interactions and stimuli, foreground and background interactions)

The interview data was analyzed by transcribing statements, and categorizing them according to the three topics listed above, to uncover patterns and similarities. These captions allow a deeper understanding of the underlying motives and effects of interactions on social connectedness.

Complementary to the interview data, the user-system interactions were logged. This was done to obtain objective quantitative measures of user-product interaction behavior. For each participant, the dataset included the amount of movement measured by SnowGlobe, the nudges that were given by the participant and whether the SnowGlobe was covered or uncovered. All logged events contained a time/date stamp.

In an attempt to quantify the effects of SnowGlobe use on connectedness, we deployed the IC-Q 26-item self-report scale (van Bel et al., 2009) on a weekly basis. The scale was used in its original form because that form had been thoroughly validated. To minimize intrusiveness of the questionnaires, filling out the scale was limited to four times during the trial. The use of this scale was complemented by an abbreviated version of the original scale. The items in this version (IC-Q 5) represent the items that were found to load highest on each dimension (van Bel et al., 2009). The IC-Q 5 was presented to the participants in a calendar form (Figure 5), to remind them to provide responses each day. We aimed for increased sampling rate, while minimizing the intrusiveness.

Figure 5. The IC-Q 5 daily questionnaire calendar.

Participants

Six seniors were recruited for the field trial. The participants were drafted from the participant database of our institute. The recruitment criteria were (A) between 60 and 70 years of age, (B) living independently and alone, and (C) being retired from work. Education and gender were treated as random variables. Each of the participants was asked to participate together with someone

Table 3. Overview of participant couples.

	Senior participant		Co-participant				
couple	gender	age	gender	age	household [a]	relationship	experiment duration [b]
1	f	60	f	62	2	friends	6
2	f	60	f	64	2	friends	8
3	f	63	m	38	3	family (mother/son)	7
4	m	63	f	84	1	friends	24
5	f	70	f	61	2	friends	41
6	m	68	f	42	4	family (father/daughter)	22

Note: [a] In most cases the co-participant lived with spouse or other family. The senior participant was alone in all cases.
[b] *Experiment duration*: the amount of days the couple participated in the experimental condition (Figure 6).

with whom they had a close relationship, but who was not living in the same place. Table 3 shows the participants who agreed to participate in the study.

As only two SnowGlobe sets (four devices) were available for the field study, and since the goal was to run longitudinal studies (at least two weeks per couple), the number of field trials was limited. The sample size ($n = 6$ couples) is in line with similar studies (Kaye, 2006; Keller et al., 2004; Romero et al., 2007; Rowan & Mynatt, 2005).

Procedure

For each user couple, the target minimum duration of each stage was one week, resulting in a experiment that lasted at least three weeks (Figure 6), and the trial consisted of three stages. The duration varied, due to the availability of the participants. Stage 1 (*baseline*) lasted for a week, and served as a baseline measurement. In Stage 2 (*adoption period*), which lasted for a week approximately, SnowGlobe was introduced into the homes of the participants, with the nudge function turned off. This stage served to let the participants adopt the new technology. In Stage 3 (*experimental condition*), SnowGlobe remained in the homes of the participants and the nudge functionality was activated, introducing richer interaction possibilities. In this stage, the experimenter did not explain what a *nudge* meant, allowing participants to assign a meaning themselves. In the case of couples 4-6, Stage 3 lasted for more than three weeks.

In the course of the study, the experimenter visited the homes of each participant three times: before Stage 1, after Stage 1, and after Stage 3. In the first visit, participants were introduced to the study. Participants were asked to fill out the *social desirability* section of the Eysenck Personality Questionnaire (EPQ) (Eysenck & Eysenck, 1991) as an additional control for Hawthorne effects, and the calendar with the IC-Q 5 was left in the homes of the participants.

During the second visit, taking place after Stage 1, the SnowGlobe prototype was installed in the living room of each participant (Figure 7). They were not instructed on how often or in what particular instances SnowGlobe should be used. To reduce the tendency of the participants to provide desirable answers, they were told that SnowGlobe was a third-party-produced prototype. The *nudge* function of SnowGlobe was enabled remotely after Stage 2, and the participants were notified by a phone call.

The final visit took place at the end of the trial, after Stage 3. During this visit a post-interview and debriefing were held. No formal post-post measurement was done on how the participants experienced the absence of SnowGlobe several days or weeks after the trial.

During each visit, participants were asked to fill out the complete IC-Q. The questionnaire was sent by mail after Stage 2, since no visit was planned. Participants were told that they could contact the researchers beyond the scheduled visits, whenever problems or questions arose.

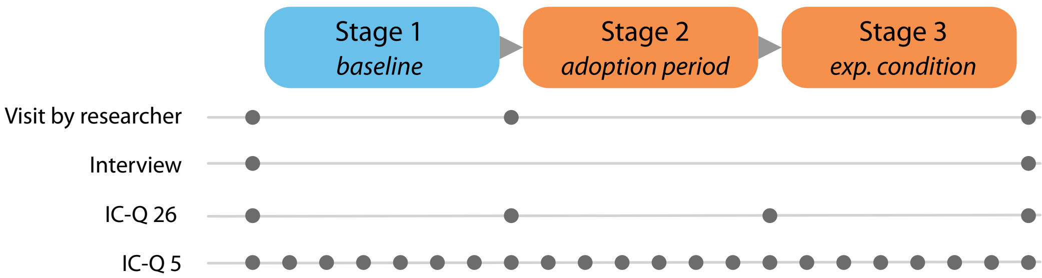

Figure 6. Schematic overview of stages and measurements during the experiment.

Figure 7. Two examples of the SnowGlobe in the homes of participants.

Results

The *social desirability* scores from the EPQ for the group of participants were similar to scores from the baseline study (Eysenck & Eysenck, 1991): Avg. 7.1 (SD 2.9; *n*=12) in the present study, compared to Avg. 7.8 (SD 2.2; *n*=849) in the baseline. The score indicates that the probability that the participants of our study responded in a socially desirable way are lower than average.

The quantitative self-report measures on social connectedness, both the original IC-Q and the abbreviated IC-Q 5 survey, did not yield significant results when compared between conditions on any of the factors. Moreover, >30% of the IC-Q 5 responses were missing. Ideally, these results would have enabled us to identify trends in social connectedness over time. However, due to a large amount of in-situ data missing, and the low amount of participants, it is not possible to present useful data along these lines.

Use and Adoption of SnowGlobe

The data log shows that SnowGlobe was used on a daily basis during the trial, by all of the participants. All couples were in Stage 3 (experimental condition) for at least six full days (main trial). Three couples (4, 5 and 6) agreed to have SnowGlobe in their homes for at least another 14 days (extended trial). In the full duration of the trial, the privacy-cover of SnowGlobe was only used five times (by Couple 6). In presenting the results, we first focus on the main trial. Next, the findings from the extended trial will be described. For the co-participants, data was normalized for the amount of people in the household. Outliers that could be linked to technology problems were removed from the dataset.

Figure 8 shows the average time of movement that was measured by SnowGlobe for both the short- and long-term trials. The figure shows that the measured movement varies greatly between couples. In particular, Couples 1, 3 (main), and 4 (extended) show long durations of movement for each day. As it is not known whether movement was created intentionally, we can not link this data to direct user-system interaction. Although the distribution between couples is large, the data shows that all participants (except for Couple 2) were able to see an average of at least 30 minutes of activity distributed over a day.

Data on amount of nudges for the similar trial periods is shown in Figure 9. The data shows that, for couple 5 and 6, the nudging activity seems to stabalize after using SnowGlobe for a longer period of time. This is not the case for Couple 4, however. The co-participant in that case indicated that, after a week of use,

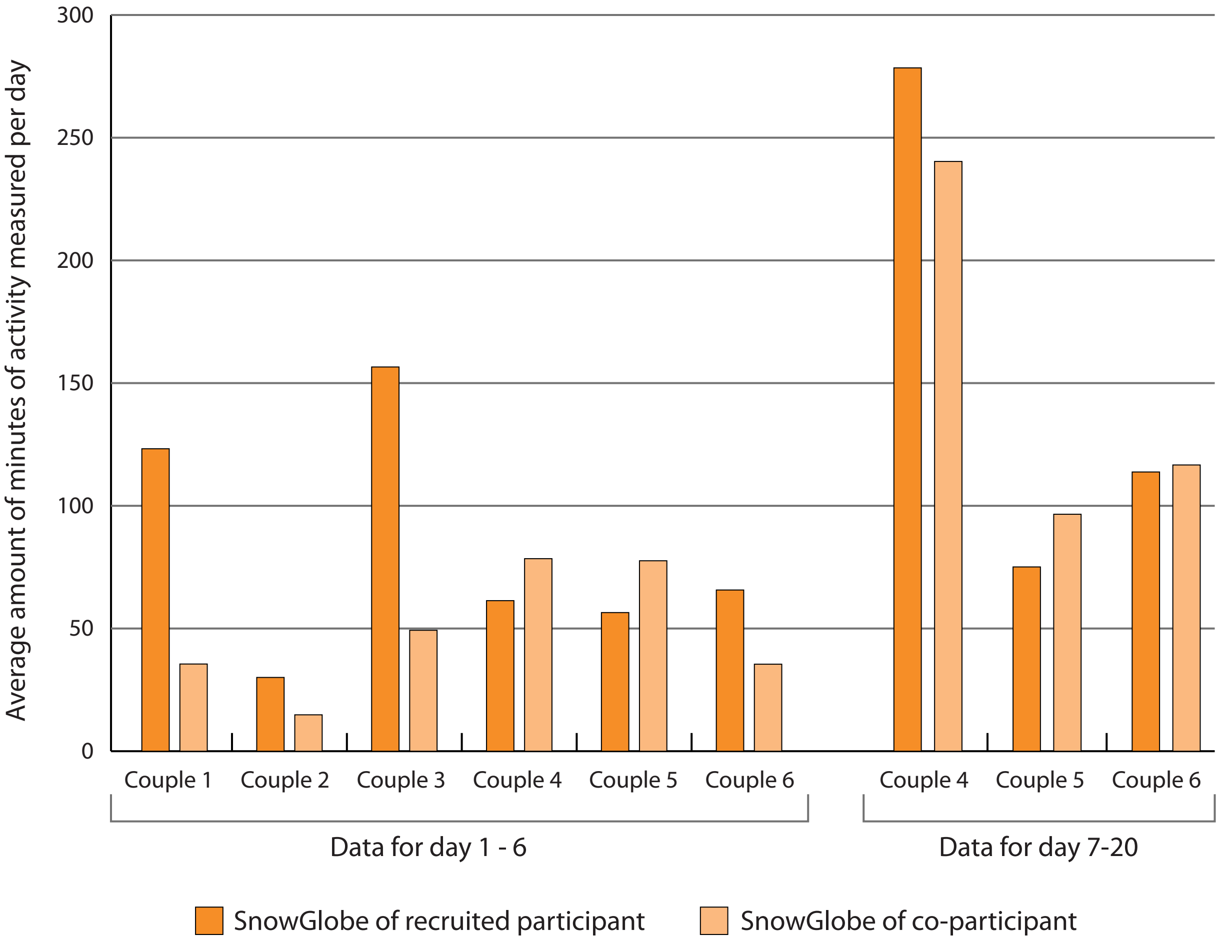

Figure 8. Average minutes of activity measured for each participant, in Stage 3.

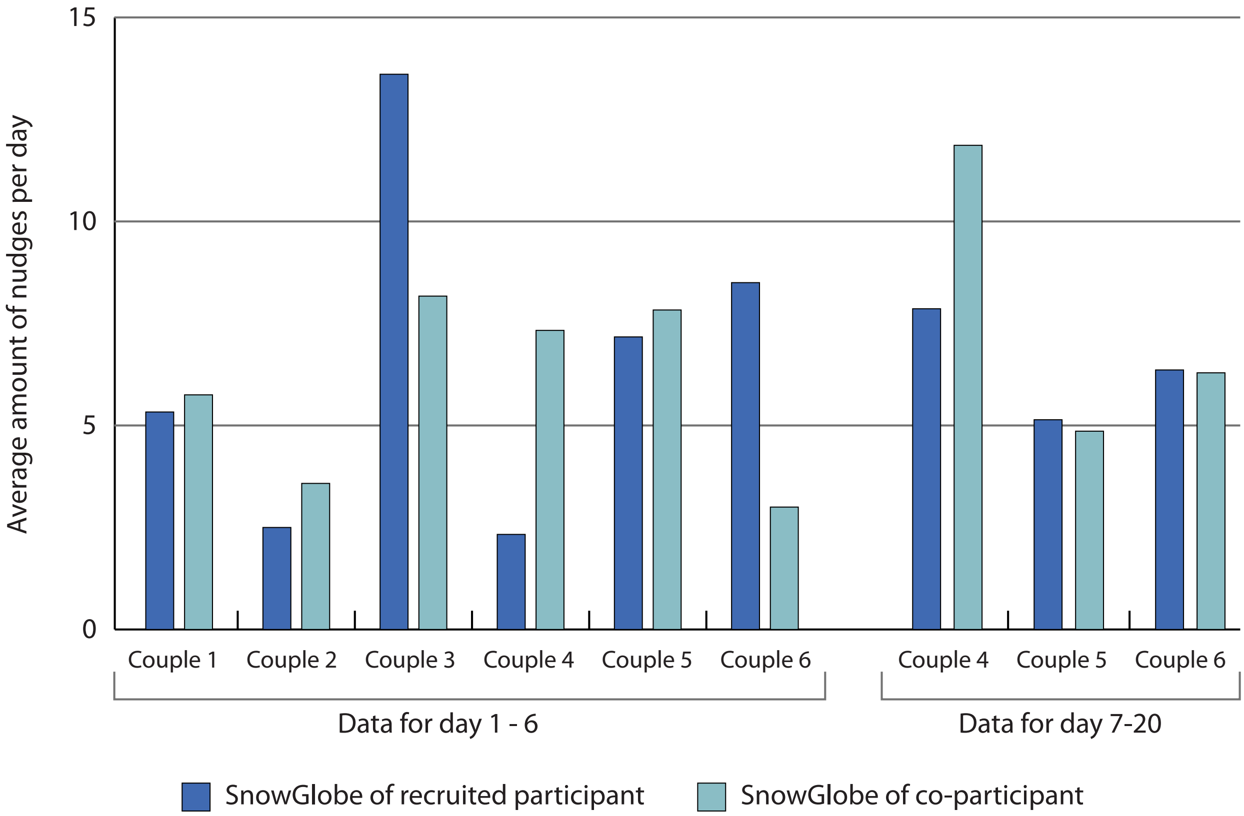

Figure 9. Average amount of nudges sent per day for each participant, in Stage 3.

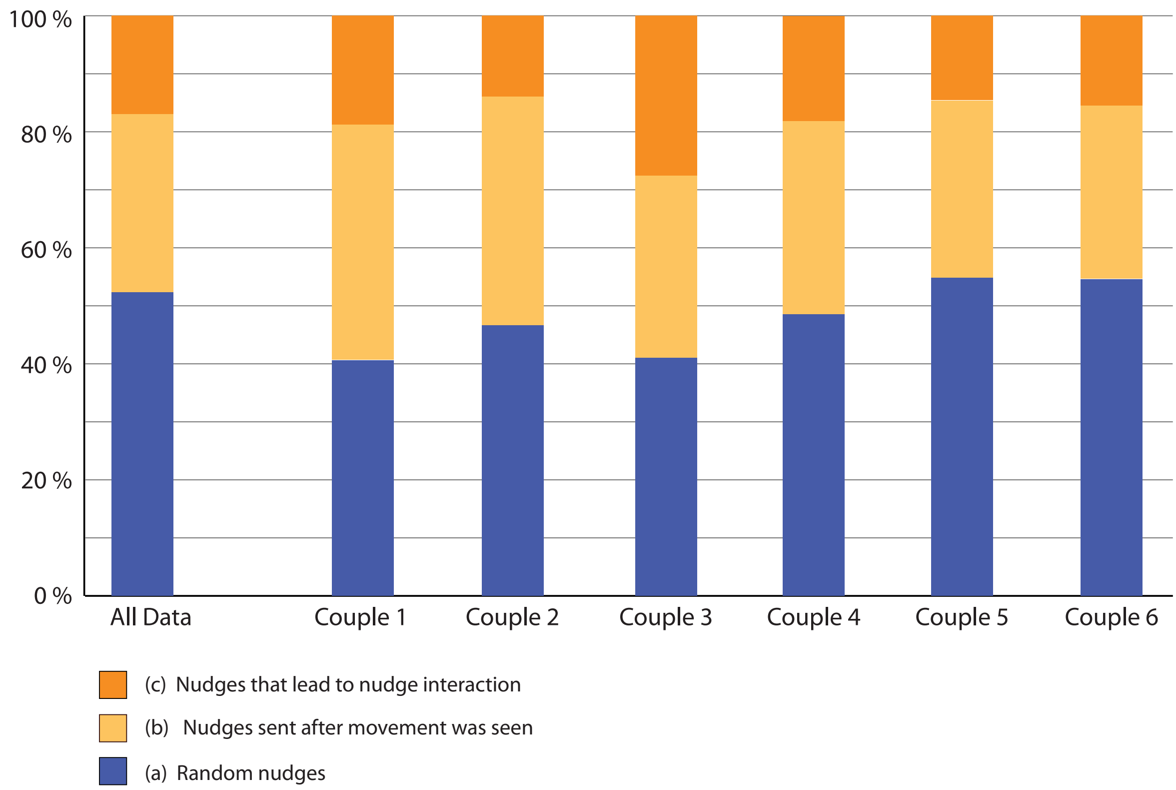

Figure 10. Three ways of nudging.

she began to increasingly use the system to keep track of where the participant was, and she also intentionally communicated her presence by moving in front of SnowGlobe (Figure 9).

In terms of nudging behavior, three cases can be distinguished: (a) a 'random' nudge was sent without observing any prior activity, (b) a nudge is sent when prior activity is observed by the participant, and (c) a nudge was sent, and the other person replied with a nudge within five minutes. Figure 10 depicts the percentage of each case, as part of the total amount of nudges sent per couple. No cases were found in which no prior activity was shown, so no nudges were returned when no motion was detected. The frequency ratio *a:b* was *1:1* and the ratio *b:c* was *1:2*, on average. Whereas the amounts of nudges and motion vary greatly between users, the ratio of nudging behaviors is more similar between couples.

Effects on Social Connectedness

Overall Experience

According to the exit-interviews, participants primarily had positive experiences using SnowGlobe, and they mentioned that SnowGlobe positively contributed to their social communication. Eleven out of 12 participants were positive regarding the adoption of SnowGlobe in their daily routines. One participant stated:

> "In a few days it became part of my life, and it is just there… I was not paying attention to it all the time." (Senior, Couple 2)

Only one participant expressed negative feelings, as he felt under scrutiny (senior, Couple 4), mentioning his co-participant was nudging him continuously and he felt obliged to respond (which is in line with Figure 9). Besides this user, no privacy problems were reported. SnowGlobe's privacy cover was only used (by Couple 6) for dimming the light.

Social Connectedness

All participants expressed an increased awareness and they reported to think more of the other than before using SnowGlobe. The following quotes from the interviews illustrates both this outcome of relationship saliency, and its temporal aspects:

> "Seeing the globe light up when he is there, affects my awareness in a way… I am more aware he is here, or I mean, there, of course. But when I get involved in other tasks, this awareness gets less again, which is a pity…" (Co-participant, Couple 6)

> "I like to nudge, just to say 'hi', or to show I'm here. I don't know why really, I just like doing it. It makes me think of her." (Senior, Couple 2)

Additionally, eight out of 12 participants reported increased feelings of social presence, linked strongly to closeness. The following quotes also touch on the physical qualities:

> "I like it when he is here while we are having coffee [participant points at, and touches SnowGlobe gently]. It feels like we're having coffee together." (Senior, Couple 3)

> "It is like she is here. She is not, of course, but the fact that she is far away fades a bit." (Co-participant, Couple 5)

Participants did not report experiences or feelings related to the direct effect of SnowGlobe on the dimensions *knowing each other's experiences* and *shared understanding*. All couples (except Couple 4) expressed, however, that the increased amount of interpersonal awareness through SnowGlobe triggered them to call or visit each other more often. In the case of Couple 5 and 6, prolonged use of SnowGlobe yielded similar results. Through these additional social interactions, beyond SnowGlobe, most participants expressed an overall increased quality of contact.

Interactions and Behavior

Participants indicated that they experienced a low threshold for using SnowGlobe. This was primarily attributed to the physical interface and subtle display, but also to the fact that response was not necessary. They had no particular expectations of a response, but they did *"like it when he nudges back."* Related to this observation, participants mentioned that they sometimes nudged at times when feeling they wanted to contact, but would not want to call, such as late at night, or early in the morning.

In seven cases, participants mentioned the ambiguity of the display. Most participants did not feel their privacy being invaded by SnowGlobe, because *"it is impossible to see what I am really doing with just a lamp."* One particular case illustrated another aspect of this ambiguity. A participant indicated that he really liked to see the activity in SnowGlobe in the morning while having breakfast.

> "[in the morning] I like to see that she's there. I know that she's having breakfast too, so we're having it together, which is really nice!" (Senior, Couple 6)

From the interview with the co-participant we learnt that she rarely ate breakfast, and was too busy in the morning to watch SnowGlobe. SnowGlobe measured movement, but the meaning attributed to the display by the senior was not in line with reality.

Discussion

The field trial aimed to understand the effect of the use of SnowGlobe on social connectedness. Moreover, a goal was to understand how SnowGlobe was used and how it was adopted. The findings from the field trial are discussed below

Supporting Social Connectedness

The exit interviews showed that SnowGlobe affected social connectedness on several dimensions. SnowGlobe positively affected *relationship saliency* and *closeness*. Snowglobe also may have an indirect effect on the dimensions *knowing each other's experiences* and *shared understanding* by stimulating use of other communication media.

According to the participants, the peripheral presence of SnowGlobe in the living room created a sense of continuous pervasive awareness of the other person. The acts of nudging and receiving nudges from the other, made users more consciously think of the other. Although one may expect that a communication of nudging back and forth would develop, this did not happen in the majority of the nudge-cases. Interview results suggest that actively interacting with SnowGlobe, even when response is absent, still makes the relationship more salient.

In addition to increasing saliency by increased social awareness, the display of motion in SnowGlobe also generated a sense of social presence. Although the display was too abstract to understand who or what was going on in reality in the other living room, users explained they experienced the display as if the other person was close to them. In several cases, users explicitly pointed to SnowGlobe, as if it were an embodiment of the other. These interactions clearly support a sense of the other person "being here". The notion that the other person is far away seems to fade away by an increased sense of social presence and closeness.

In an indirect way, SnowGlobe stimulated other dimensions of social connectedness (*shared understanding* and *knowing each others' experiences*) by triggering the use of other communication media. This supports the notion that an SA-system should be considered as complementary to existing media, rather than as a substitute. In many cases, the pervasive and simple interactions of SnowGlobe may trigger further conversation, guiding them from social awareness into more involvement into each other's lives, sharing thoughts and experiences. In this way, the SA-system is also a trigger for deeper communication, similar to the way small-talk sets the stage for richer conversations in verbal communication (Vetere, Smith, & Gibbs, 2009).

Interactions and Meaning

All participants actively used SnowGlobe throughout the entire duration of the field study, suggesting that the system succeeded in maintaining user engagement. The amount of nudges per day was, on average, five to six (extended trial, Couples 5 and 6).

Participants did not send nudges to set up a dialogue, and did not feel disappointed if no reply followed their nudge. However, participants indicated they did appreciate a nudge-reply. The log-data on nudging even shows that in 50% of the cases, users nudged without seeing activity in their globe, indicating that the other person was not present. These findings suggest that reciprocity was not required for feeling connected through nudging.

SnowGlobe's tangible form and interactions were highly valued by participants. The form factor enabled intimate interactions and created a sense of virtual presence through the device. Also, having a physical device in the living room was experienced as a low threshold for interaction, which may also have had an influence on the strategies of nudging described above; one did not have to start the computer or log in to try a nudge. Additionally, the participants found the activity of shaking SnowGlobe an intuitive action for a nudge.

It was clear for users how the displayed cues were evoked, and how their actions changed the display in the other SnowGlobe. Beyond that level, users formed their own interpretation of what was going on in the other person's living room (e.g., *"She is probably preparing breakfast."*), which supported their sense of closeness, but was not always in line with reality. Nevertheless, users did not express a desire for more accurate or detailed awareness; rather they expressed appreciation for SnowGlobe's ambiguity. This feedback suggests that SnowGlobe's ambiguity is sometimes a stimulus to think of the other person, and to imagine what the other would be doing at that moment, rendering the exact activity less important. At the same time, the ambiguity qualities of SnowGlobe, protect the privacy of users by not clearly displaying the situation in the other living room. This sense of privacy is underlined by the fact that participants rarely covered SnowGlobe.

Design Insights

This section describes the primary design insights from the study, which may be used in future designs of SA-systems They are summarized as follows:

Low Bandwidth. Simple interaction and displays, such as motion awareness and *nudging*, are adequate to increase *relationship saliency* and *closeness*. Besides having an effect on social connectedness directly, it may also serve as a kind of small-talk before richer communication through other media. For stimulating other dimensions of social connectedness, designers should search for higher bandwidth, which includes sharing more content.

Ambiguity. Displaying abstract information that can be interpreted in ambiguous ways is powerful in two ways: (1) It stimulates the user to think actively about what their relative is doing and (2) it decreases expectations of reciprocity in terms of social interactions and increases privacy.

Physicality. Tangible interaction, with a physical device as medium, can provide a sense of intimacy that may be harder to achieve using screen based interfaces. Physical interaction lowers the threshold of use, as well as the adoption of it in daily routines. This may be harder to achieve using more traditional screen based interfaces.

Conclusion

A challenge in the design and evaluation of social awareness systems motivated us to develop SnowGlobe. Despite the body of work already available in this domain, it has been difficult for designers to identify how these systems affect social connectedness. This paper suggested an approach in which we first identified the dimensions on which communication systems may affect the experience of social connectedness. Using this outline of social connectedness it was possible to purposefully design several prototype awareness systems, which were used to identify key potential interactions for social connectedness. Using this primary knowledge on how the design may affect connectedness, we developed SnowGlobe as an SA-system that could be evaluated in a field context for a longer period of time.

SnowGlobe was designed to stimulate social connectedness by increasing relationship saliency and closeness between two users. It enabled interpersonal awareness of motion and it allowed users to send a *nudge* by shaking the device. A field evaluation with six couples of users, ranging from at least six days to >20 days for three of those couples, provided interview data and interaction logs.

Analysis of the data showed that peripheral interpersonal awareness of movement in the living room supported relationship awareness and social presence. The active communication function of nudging contributed to relationship saliency, by making users think more of each other when sending or receiving nudges. Additionally, it was found that the physical shape of SnowGlobe lowered threshold for using, and increased a sense of social presence.

Limitations of the study are related to quantifying the individual effect of different interactions with the system on social connectedness. Also, it was not possible to understand how social connectedness develops over time. It seems that for a field context, the scales used were not appropriate for a dynamic field environment, resulting in high variances and missing data (due to experienced burden). This suggests the need a need for instruments that, ideally, enable measuring social connectedness close to the interaction with the system.

The primary contribution of this work to the field is the deeper understanding of how user-system interaction supports social connectedness. By carefully choosing a theoretical definition of social connectedness and strongly integrating its dimensions in the design process, we have been able to identify and understand key interaction features of an SA-system for supporting connectedness. Although the present study focuses on SA-systems only, a similar approach may be valid for other forms of computer-mediated communication.

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