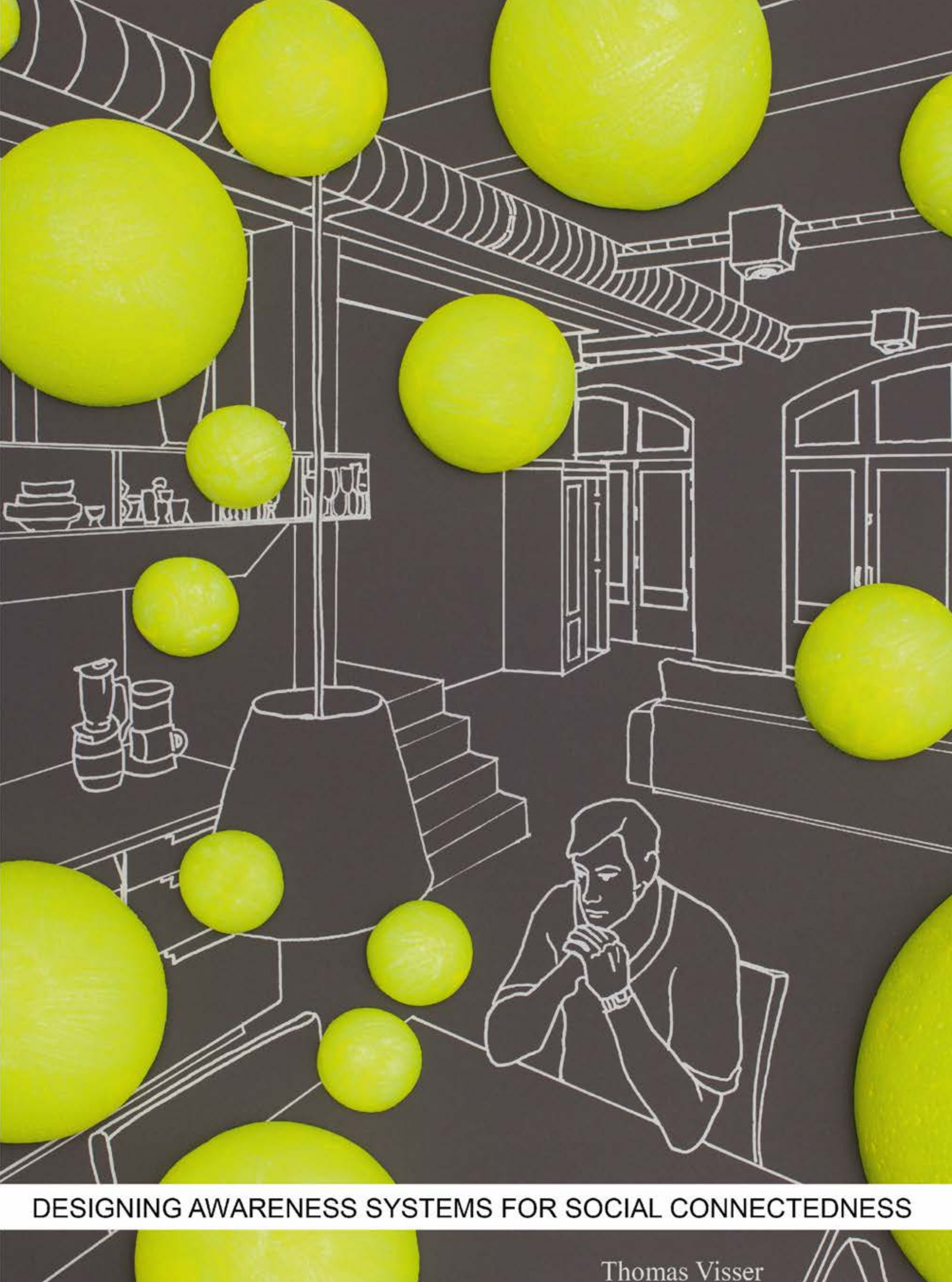

DESIGNING AWARENESS SYSTEMS FOR SOCIAL CONNECTEDNESS

Thomas Visser

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Designing awareness systems for social connectedness

A field study approach into theoretical foundations, design principles and evaluation

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“Good judgment comes from experience,
Experience comes from bad judgment.”

Nasrudin, 13th or 14th century

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1 Introduction

When a good friend says 'hi' to you at the beginning of an online chat session, you may feel a bit more connected to him, without actually chatting with each other. Also, when you see a close relative come online on a social network, even without having a conversation you know something about him – he is at his computer – and you may feel some connection, just by thinking about him. Although such subtle social cues may not always be intentionally created, they constitute a valuable contribution to ones social well-being and sense of social connectedness.

The communication of such subtle cues may be particularly valuable for people in relationships where more social awareness is desired, but in-depth conversations are not always necessary to maintain a sense of closeness. For when families are dispersed across the country, the communication between parents, grandparents and children may benefit from a more continuous sense of being connected. Although awareness technology exists in the form of desktop and mobile applications, additional user-benefit could possibly be attained when the communication platform is presented in a more pervasive manner, integrated in our everyday environment. Displays could be more perceptible yet not intrusive, and lightweight interactions could enable users to perform simple communication related tasks.

Awareness technology can be embedded in homes as products integrated in the daily lives of people. Imagine a flower in your living room that blooms whenever your daughter, comes home from work; or imagine a lamp in which the brightness depends on the amount of noise in the home of a relative, and when you squeeze your lamp, the other lamp blinks; or imagine a music box that plays a specific song when one of your best friends is moving around in his living room, you could have different songs for different friends. Concepts such as these have been developed and investigated in the recent years, and they are referred to as s. They enable users to maintain a more pervasive and continuous awareness of close relatives or loved ones when desired.

Social awareness systems can be characterized as systems embedded in a daily life context that display information about a close contact in the periphery of our attention. Social awareness systems introduce entirely new ways to increase people's social well-being by making them feel more connected. They may enable a ubiquitous and extended sense of connection, in particular when one does not actively consider engaging in formal communication via spoken or written communication. In some cases they may allow simple active communication (i.e., squeezing a lamp), but they generally rely on data automatically collected by sensors (e.g., a sound sensor). In this dissertation, a social awareness system is defined as a product and/or service, embedded in the environment, which provides awareness information about people within ones social network.

There is a fundamental difference in how awareness systems and traditional communication technologies support communication. Awareness systems are 'always on', they act in the background of the users' attention, and they do not require active user involvement. As meaningful data is automatically collected and displayed by the system, users do not necessarily have to take initiative or express particular intentions; the communication 'just happens'.

The premise of social awareness systems is promising: it can enable people to pervasively maintain a feeling of being connected in their changing lifestyles, despite increasing physical distances between relatives. However, the actual effects such systems may have on social well-being are unclear. Previous studies indicate that researchers have struggled to quantify these effects. They have primarily focused on the conceptual design and short-term, informal evaluation, which does not help to understand changes in experience over the long term. In addition, the few evaluations of systems that have been done in real-life contexts for longer periods of time, expose a lack of appropriate measurement instruments that can quantify the user experience.

Insights into factors influencing the use of social awareness systems and the effects on social well-being, may help designers to more effectively design systems for social well-being. This dissertation therefore aims to provide an answer to the following main question: How can social awareness systems be designed to support social connectedness through subtle interpersonal communication?

Social well-being and social connectedness

Social awareness systems generally aim to improve people's social well-being by making them feel more connected. In this section, an outline is provided on the theory underlying social well-being.

Social well-being is considered to be a pervasive and powerful human need (Ormel, Lindenberg, Steverink, & Vonkorff, 1997; Ryan & Deci, 2000). For several decades, research in psychology and social sciences has shown that the social aspects of life contribute significantly to overall well-being. Maslow (1968) suggested that love and a sense of belonging are important contributors to well-being, together with physical comfort such as safety and security. 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). Not belonging to a social network has been found to be highly aversive

(Case & Williams, 2004). The pervasive drive for social contact can be explained by the evolutionary advantage of belonging to a group, which is evident throughout history, and appears to be inherent to mankind.

Social well-being is primarily determined by concepts such as a sense of belonging, relatedness and attachment (van Bel, IJsselsteijn, & de Kort, 2008). These constructs address a long-term affective state, and they account for ones complete social network and stimuli, rather than individual relationships and interactions. Therefore, they are not easily changed by a individual social interactions (Reis & Patrick, 1996). Concepts, such as social status and behavioral confirmation also affect social well-being (Ormel et al., 1997), but they do not address interpersonal relationships directly. Thus, these are not part of the current scope.

To be able to understand the effects of specific interactions with communication services, a construct is needed that addresses short-term experiences. The term social connectedness was coined to address "*…the momentary affective experience of belonging.*" (Rettie, 2003). A prolonged increase of social connectedness supports belongingness and social well-being. The construct was further developed by Van Bel et al. (2008) to address experiences 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 other's experience, both in terms of subjective experiences (e.g. 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 concept social connectedness seems to be a suitable construct for both the design and evaluation of social awareness systems: it addresses momentary experiences, it accounts for subtlety in experiences, and it directly relates to interpersonal relationships. When building novel products and services, designers could aim for 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.

Peripheral communication

Social awareness systems can support humans in fulfilling their intrinsic need for interpersonal contact. These systems generally rely on generating and communicating subtle social cues, often in the background of our attention. In many cases the emphasis and effect of the cues is based on creating contact, rather on communicating emotional content or ideas. Consider the following scenario:

> *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 neighbor 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 encounters described above, Kevin experiences two different subtle social cues; each temporarily affecting Kevin's feeling about a relationship. Both encounters are not characterized by the exchange of content or experience, but nevertheless confirm the existence of a relationship. In the first encounter (Mike's car), communication was created non-intentionally, and it is provided through a pervasive awareness of the contextual environment. In the second case there is intentional interaction with another person, in which Kevin and the neighbor.

Jakobson (1981) has developed a model on communication that explicitly separates the contact-factor of communication, from message content and the context of the communication. The model (Figure 1.1), which focuses on intentional communication, considers the contact to be made and maintained by the phatic function of communication. The phatic function serves to confirm the connection between sender and receiver, without conveying content or experiences.

The phatic function of communication has been studied in linguistics, as an explanation for small talk (e.g. talk about the weather) (Malinowsky, 1923; Schneider, 1988). This function helps people to ground future communication and interactions (Clark & Brennan, 1991). Phatic communication has also been studied in online contexts, and it is considered one of the most important motivations for using services such as Facebook, Twitter and several online messengers (Zhao & Rosson, 2009). It has been suggested that the emergence of such online technologies has created a Phatic Culture (Miller, 2008), in which phatic communication gains more importance, relative to communicating ideas and experiences. In the domain of ubiquitous computing, explorations have been conducted to understand how phatic functions can be supported through computer-mediated communication. Phatic interactions (Vetere, Smith, & Gibbs, 2009) are considered important for creating common ground in a relationship.

In addition, awareness systems have the potential to support the sense of contact through non-intentional awareness cues. This type of communication is based on the automatic communication of data about each other's activities or whereabouts (Markopoulos, 2009). In mediated communication, several studies have examined this effect in the context of online social messaging. Connectedness is increased when from behind a computer, the online/offline status of a friend appears to automatically update (Dey & Guzman, 2006). Awareness of physio-social information (i.e. the interpersonal communication of heart rate) about a contact

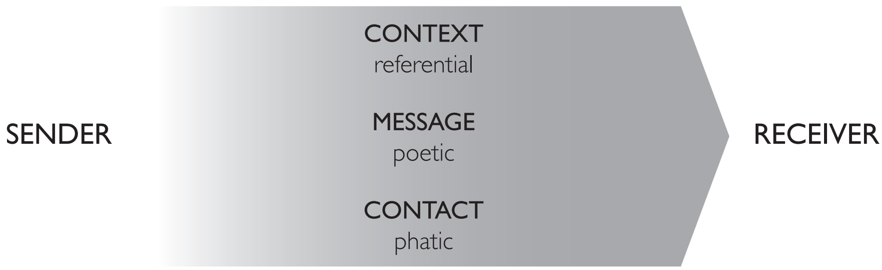


Figure 1.1. A simple communication model adopted from (Jakobson, 1981).

has shown to increase a sense of social intimacy (Janssen, Bailenson, & IJsselsteijn, 2012). No controlled studies were found on how peripheral awareness of social information affects social connectedness.

Both awareness-cues and phatic-cues, being subtle social cues, seem to have a potential positive effect on social connectedness. This has been partly confirmed in previous studies. It is nonetheless unclear how the two forms of subtle social cues relate, and to what extent they may influence the sense of connectedness between two individuals remotely located from each other, in a real-life context.

Social awareness systems

Interpersonal awareness

Use of the Internet can be considered as a key example of how technology can be used to mediate communication over a distance. Communication ranges from concrete messages to implicit social cues. As an example, micro-blogging services, such as Twitter[1], have been found to support a sense of connectedness by enabling people to stay in touch, without necessarily communicating content. Facebook[2] enables users to form a pervasive awareness of what is going on in ones social network, and it lets people *like* and *poke* each other, as means of phatic communication. Online messenger services provide a sense of interpersonal awareness by showing the *online*, *away* or *offline* status of a list of friends, which can be considered to be awareness cues (e.g. Skype and Microsoft Messenger). They are however less pervasive than real world encounters, as users have to log in using a computer or mobile device.

In everyday-life people obtain information from the periphery of their attention. For example, one may note that rain may be coming just by the change in color of the daylight. In a similar way, people may obtain information about other humans, such as by a car being parked in front of a house, or the lights in a living room of a house being turned on. Modern technology enables to 1) sense these subtle events, 2) communicate them easily through the Internet, and 3) display

1. http://www.twitter.com retrieved 9/9/2012

2. http://www.facebook.com retrieved 9/9/2012

Table 1.1. Social awareness systems clustered based on their user-system interaction type and intentionality of communication. The text in bold indicates longitudinal evaluations > 2 weeks.

	AWARENESS CUES non-intentional	PHATIC CUES intentional
SCREEN BASED	**Awareness Display** **Digital Family Portrait** **Solar Display** **Portholes** **CareNet** Media Spaces Daily Activity Diarist **Whereabouts Clock**	**Virtual Intimate Object** **ASTRA** **The Cube** Photomirror
TANGIBLE	Gust Bowl	Feather, Scent, Shaker Lampshade Hug-at-a-Distance Lumitouch

them in such a way that the users unobtrusively perceive them. This may enable people to increase their feeling of social connectedness, beyond what is achieved with more traditional communication means, such as phone calls and e-mail. Systems supporting this type of mediated communication are commonly referred to as *awareness systems* (Markopoulos, 2009).

Early examples of awareness systems were not explicitly aimed at supporting social connectedness. They focused on work environments, and have their roots 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, supporting a sense of presence over a distance (IJsselsteijn, Freeman, & De Ridder, 2001).

In line with the more recent vision of Aarts & Marzano (2003) on ambient technology, researchers have shown an emerging interest in awareness systems for the home and leisure context. Cases include connecting seniors to their family, parents to their children that are in college, and communication between dispersed loved ones.

The social awareness systems described in the research community can be categorized based on the type of communication they facilitate: pervasive social

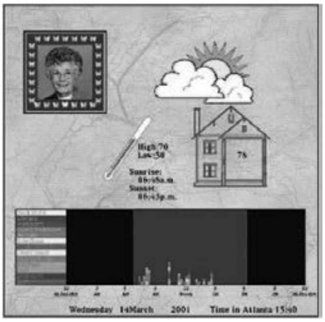


Figure 1.2. The Family Portrait photo frame with monitored data displayed.

Figure 1.3. The ASTRA awareness display, showing shared pictures.

awareness and/or phatic communication. Often, systems could be put into more than one category because they facilitate multiple levels of communication. Systems that enable the communication of ideas and experiences are not within the scope of this dissertation, as they tend to draw very close to traditional computer mediated communication (e-mail, chat boxes, etc.).

In addition, systems could be classified based on whether the system is screen-based, or has a more decorative appearance that is embedded in the natural user context. In the latter, systems are often designed using principles from tangible and embodied interaction, as these seem to convey more intimate and emotional interactions (Rittenbruch & McEwan, 2009).

This classification can be outlined in a framework. Table 1.1 includes the most cited works since the pioneering work. In the table, those systems that have also been evaluated in a longitudinal (>2 weeks) field context are shown in bold. Although some examples of audio-based systems are known, these are not included in the current framework, as these primarily focus on awareness of non-social information (e.g. Home Radio and Birds Whispering (Eggen & Mensvoort, 2009)).

Screen based awareness systems

The Digital Family Portrait (Figure 1.2; Mynatt, Rowan, Jacobs, & Craighill, 2001) project has become a classic example of a screen-based social awareness system. DFP is a system that shows automatically collected information about the location and activity of a senior to the son or daughter on a digital photo frame. In a field study (Rowan & Mynatt, 2005), users reported increased feelings of being connectedness, even though DFP is based on one-way monitoring only.

More recent projects that rely on the automatic collection and display of monitored user data are Solar Display (a social interaction monitoring system) (Morris, 2005), CareNet (Consolvo, Roessler, & Shelton, 2004), and Daily Activity Diarist (Metaxas, Metin, Schneider, Markopoulos, & de Ruyter, 2007) (both care monitoring systems), and MarkerClock (Riche & Mackay, 2007) (a display of the routines on a clock-interface). These concepts all focus on monitoring senior users, to foster peace of mind and connectedness for the informal caregivers.

Some systems, such as the ASTRA project (Figure 1.3; Romero, N., Markopoulos, P., Baren, J., de Ruyter, B., IJsselsteijn, W., & Farshchian, B., 2007), are designed for in-home environments, supporting family members to send and receive images and text between a mobile phone and a pervasive display in the living room. The system was evaluated both in a laboratory and in the homes of two families. Affective benefits were found using the ABC-Questionnaires (IJsselsteijn, van Baren, Markopoulos, Romero, & de Ruyter, 2009), but the effects of individual interactions on social experiences could not be identified. Photomirror (a photo exchange system) (Markopoulos, Bongers, van Alphen, Dekker, van Dijk, Messemaker, et al. 2006) is a service that, similar to ASTRA, supports the exchange of images. However, the imagery is collected unobtrusively within a home context, supporting social awareness, rather than phatic communication.

Similar in terms of within-family use, but focused on interpersonal awareness of location, is the Whereabouts Clock (Brown, Taylor, Izadi, Sellen, Kaye, & Eardley, 2007). Positioned in the living room, it automatically displayed one of three locations in which family members may be: school, home, or work. In addition, family members could send text messages to the clock. A longitudinal qualitative study suggested that despite low resolution and frequent technology failure, family members experienced increased feelings of being in touch. During the trials, message sending was not used frequently (less than 2 per week).

Dey & 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 lover. Increased feelings of a ‘being in touch’ interpersonal awareness were reported in the study. This display is similar to a feature of many online services, such as Facebook, Twitter, Microsoft Messenger, and Skype, in which users’ online status is displayed in a list of ‘friends’, providing some social awareness about the friend.

Similar in terms of design, 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 intentionally 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. The Cube (Howard, Kjeldskov, Skov, Grarnces, & Grünberger, 2006) provides a similar sense of “contact without content” by enabling users to send small poke-like messages between mobile devices. Both designs are enablers of phatic communication, without providing additional social awareness.

Screen based social awareness systems, such as those described above, aim at providing awareness cues as the primary means of communication. Limited endeavors have been made into the realm of phatic communication (e.g., VOI and Cube). There appears to be very few screen-based studies and design work that explore a combination of awareness and phatic communication within a single system (ASTRA, Whereabouts Clock), and these did not concern relatives that were living apart from each other.

Figure 1.4. The GustBowl awareness system.

Figure 1.5. The Lampshade intentional presence lamp.

Tangible awareness systems

Where the projects above considered screen-based interactions, there is a plethora of social awareness system projects that take an approach involving tangible interaction (Ishii & Ullmer, 1997). Tangible and physical interactions can emphasize and articulate the user experience through embodiment (Dourish, 2001) and affective loops (Sundström, 2005). Therefore, it is not surprising that systems relying on tangible and embedded interaction are often considered to be more intimate and emotionally meaningful (Rittenbruch & McEwan, 2009). Also tangible interfaces in general are closer to the visions of Ambient Intelligence (Aarts & Marzano, 2003) and The Internet of Things (Gershenfeld, Krikorian, & Cohen, 2004), in which technology is pervasively embedded in the user context, without a need for dedicated input devices and displays, such as (touch) screens and mobile phones.

The well-known and seminal work by Strong & Gaver (1996) prepared their academic manifesto on *provocative awareness* (Gaver, 2002). The concepts (Feather, Scent and Shaker) emphasized the poetic expression of awareness information; the prototype of *Feather* consisted of a small portable box, which can be opened to see a picture of a loved one. Opening the box triggered a feather to float down in a glass tube that is located in the living room of the loved one.

In the wake of these designs, multiple social awareness systems were developed as part of research projects. Similar to Feather, The GustBowl concept (Figure 1.4; Keller, van der Hoog, & Stappers, 2004) also integrates daily routines, supporting communication between students and parents. In the GustBowl design, the student places a small personal object in a bowl, which is then photographed and displayed in the parents' bowl, giving him or her a peek into the life of their child. Both Feather and GustBowl consider an interaction principle that is between awareness (automatic data collection from routines) and phatic communication (users intentionally opening the box or placing keys).

Two examples of tangible social awareness systems that rely on phatic communication are the Lampshade mock-up and LumiTouch. The first was built as part of the Casablanca project (Figure 1.5) (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. The LumiTouch system (Chang, Resner, Koerner, Wang, & Ishii, 2001) connects two photo frames where one lights up when the other is touched.

The Hug-over-a-Distance vest (Müller et al., 2005) embedded the intimacy of tangible communication in a literal way. It enables people to exchange physical expressions (e.g., patting and hugging) over a distance, using force sensors and vibration motors. This conceptual design aimed to approach physical intimacy, and it may therefore be less suitable for non-romantic relationships.

In terms of interaction design, the designers involved in the projects described above stress the importance of aesthetic quality of interaction (Keller et al., 2004; Strong & Gaver, 1996), the integration of the system in the user context (Gaver, 2002; Hindus et al., 2001; Keller et al., 2004), and the qualities of tangible interaction (Chang et al., 2001; Müller et al., 2005). However, none of these systems were exposed to formal evaluations. It is therefore unclear whether the interaction principles designed into the systems foster a sense of social connectedness on the long term, and how this is related to user system interaction functionalities.

Research approach

Research focus

The primary goals of this dissertation are to create a fundamental understanding of 1) how subtle cues can be integrated in the user environment through social awareness systems, and 2) what the effects of such systems are on the social user experience. The aim is to build on social well-being theory and interpersonal communication, to better understand how social connectedness can be affected by using social awareness systems. Additionally, the research outcomes should help designers of mediated communication systems to better focus their designs towards supporting connectedness. Towards meeting these goals, this dissertation takes the following focus:

Social connectedness

The construct social connectedness, which relates to momentary affective experiences, is used to guide the design and evaluation process. Whereas the widely used Affective Benefits and Costs (IJsselsteijn, van Baren, Markopoulos, Romero, & de Ruyter, 2009) is limited to the experience of a product intervention, social connectedness covers the experience of a social relationship. As such, the evaluation of social connectedness is less prone to social desirability biases. When studying both short-term and long-term effects of social awareness systems, one needs to measure the changes in perceived connectedness in time. Guidelines are readily available for evaluating social connectedness (van Bel, Smolders, IJsselsteijn, & de Kort, 2009); these guidelines are used in the research in this dissertation.

Subtle social cues

The basic principle of a social awareness system is that it supports awareness of social cues in the periphery of people's lives. Therefore, the focus of this dissertation is primarily on subtle communication, i.e. both awareness and phatic communication (Table 1.1). Since awareness systems are less suitable for supporting richer communication, such as the sharing of ideas or experiences between users, this is left out of the scope of the current work.

Tangible awareness systems

A review of available literature exposed that tangible awareness systems seem very appropriate for fostering affective social experiences through their embodied nature. A focus on tangible, rather than screen-based systems was chosen since tangible systems are considered to be more emotionally meaningful (Rittenbruch & McEwan, 2009). Many inspiring prototypes of tangible systems were found, but none were formally evaluated in a real-life context, which is considered essential for understanding how ambient and peripheral technologies affect our lives. In addition, most examples do not exploit both intentional and non-intentional communication principles in their design. This is a domain open for exploration.

At the start of the research described in this dissertation, the mobile application (App) culture did not yet exist. In view of the current trend and the growing amount of social Apps, the relevance of studies into tangible awareness systems could be questioned. Indeed, if the project had started today, parts of the research would probably have been conducted using an App, as it would make the studies more efficient. The tangible research prototypes are important, however, for providing valuable insights into the underlying principles of subtle communication and social awareness. Moreover, they enable to study the design and perception of mediated subtle social cues that are fully integrated in everyday life. It is expected, that the insights created into the underlying principles of subtle communication will be useful for designers of both App and tangible user interface solutions.

Research questions

Considering the research goal and focus described in the previous section, the main research question was formulated as follows:

How can social awareness systems be designed to support social connectedness through subtle interpersonal communication?

This main question lead to the following sub-questions:

1. How can theory on subtle communication be operationalized in the design of social awareness systems?
2. How do the subtle *awareness* and *phatic* cues contribute to social connectedness?
3. What interaction principles play a role in stimulating a sense of social connectedness between users through human-device interaction?

Throughout the research process a fourth research question emerged:

4. How can subtle changes in social well-being be measured in a real-life context?

Outline of this dissertation

The relationship between mediated subtle communication and experiences of social connectedness has not been widely studied. To gauge the individual effects subtle social cues, a controlled web-study was set up, exploring the effects of awareness and phatic online communication between users that did not know each other (Chapter 2).

An Empirical Research Through Design approach (Keyson & Bruns Alonso, 2009; Zimmerman, Forlizzi, & Evenson, 2007) was followed to explore design options in the domain of tangible social awareness systems and subtle social cues. Insights obtained on suitable interaction and communication principles gained in the design and the development of several prototypes, were used in the development of research probe called SnowGlobe. This final design would be used as a research probe in further field studies (Chapter 3).

The effect of longitudinal use of SnowGlobe was explored in a field study. The goal of this study was to create a general understanding of how the designed interaction and communication features affect the user experience of social connectedness (Chapter 4).

The longitudinal field study with SnowGlobe identified a challenge of collecting *in-situ* user reports on connectedness, close to interaction events. The Closeness Slider measurement instrument was designed to address this challenge. The instrument was first validated in a controlled lab study, followed up by two field pilot studies (Chapter 5).

A final field study with SnowGlobe was conducted to capture short-term effects on social connectedness. The Closeness Slider was used to sample experiences of closeness close to the user-system interaction. The aim of the study was to understand the effect of awareness and phatic cues in a field context (Chapter 6).

A discussion on how social awareness systems support social connectedness is provided at the end of this dissertation. This section also discusses the limitations of the research, the effectiveness of the research methodology, and possible directions for future work (Chapter 7).

1 Introduction

2 Subtle social cues in an online context
- online experiment
- understanding of the effect of awareness and phatic cues

Web study

3 Design explorations of social awareness systems
- empirical research-through-design cycle
- development of SnowGlobe research probe

Design study

4 Longitudinal effects on social connectedness
- understanding of effects of social awareness systems
- interaction principles in a real-life setting

Field study

5 Design and validation of the closeness slider
- measuring short-term connectedness
- validation of field study methodology

Lab study

6 Short-term effects on social connectedness
- detailed insights on effects of subtle social cues
- short-term effect of user-system interaction

Field study

7 Discussion

2 Subtle social cues in an online context

This chapter describes an online experiment that aims to better understand the effect of different subtle social cues on the user experience of social connectedness. First, related work on awareness communication and on social media use is presented. In the experiment, participants communicated with an online participant either through phatic or awareness based communication in an online task, and rated their sense of connectedness towards the online participant. The design of the online task is described, the experiment procedure is provided, and the value of each of the two functions for supporting connectedness is discussed. Also, a reflection on the value of the findings for the further design of awareness systems is provided. The results of this study contribute to an understanding of subtle communication principles, helping designers to understand the effect of designed communication applications.

Introduction

Being aware of what is going on in one's own social network is easier than ever. In many different ways, online services and mobile devices and applications allow us to maintain a peripheral awareness of our relationships. Generally, researchers in telecommunication have agreed that increasing communication richness positively affects closeness and intimacy (Short, Wiliams, & Christie, 1976). However, minimal communication also has significant importance for interpersonal relationships through establishing and consolidating social connections (Schneider, 1988).

Before the 1990s, communication tended to demand dedicated attention and focus (e.g. writing a letter, making a phone call, visiting a friend). Today it is more and more common to have one's social awareness and contact through events that happen in the periphery of our attention as subtle social events (e.g., people coming online on instant messaging services, or *poking* someone on Facebook) (Miller, 2008). This indicates a shift in focus from narrative content to a peripheral sense of being-in-touch.

The emerging communication technology enables people to send and receive subtle social cues whilst being involved in other tasks. These subtle cues may be produced without particular intention (e.g. coming online) as awareness cues, or with intention (e.g. poking) called phatic cues (Vetere, et al., 2009). Interestingly, the evidence on the effects of mediated subtle communication on people's sense of social connectedness is mixed: some research suggests that awareness and Facebook poking support social connectedness (Romero et al., 2007; Visser, Vastenburg, & Keyson, 2011), whereas others found *poking* to be perceived as unimportant (Bumgarner, 2007). Whether poking affects closeness and connectedness more than pervasive awareness remains an open question.

The research presented in this chapter aims to understand how people interpret awareness and phatic online social cues. An experiment was conducted with participants who were told that they were evaluating an online movie-reviewing system with an online partner (a pre-programmed confederate) shown through one of four different types of social cues. A confederate-setup was used to obtain full experimental control in all conditions. The experience of connectedness, closeness and liking were compared across conditions. As the presence of intention in a cue was expected to stimulate connectedness, it was expected that the phatic cues in the experiment fostered a higher sense of connectedness of the participants.

Design of an online experiment

To investigate the relationship between different types of online social cues and the experience of online connectedness, an experiment was conducted in which participants engaged in an online task with an online confederate. The experiment was conducted through a website where participants viewed four movie trailers in randomized order and wrote a short review of each trailer. Participants were told that they performed these activities concurrently with an online partner, to whom they were ostensibly coupled based on their personal profiles. Participants were provided with visual cues to support awareness of the activities of the confederate (Figure 2.1 and 2.2):

1. No icon (control)
2. An icon as a reminder of the partner's presence (random reminder)
3. An icon of the partner's keystroke activity (awareness)
4. A poke icon that could be actively pressed (phatic)

Regardless of the condition, the icon on the participant's screen turned red (randomly, or indicating the partner's keystroke-press or poke) at set times, averaging 2-5 times per minute. In the *poke*-condition, the screen also included a button to poke the online partner.

Figure 2.1. Three of four experimental conditions.
From left to right: Reminder, Keystroke and Poke.

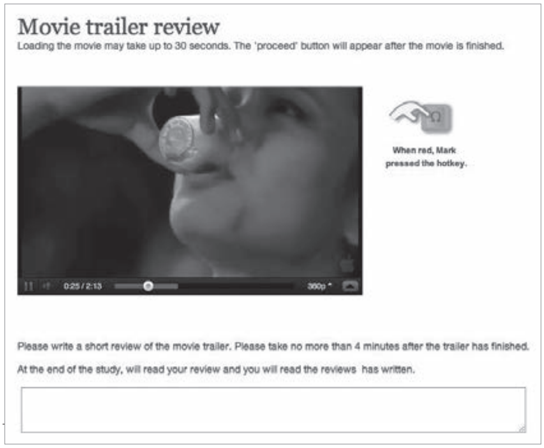


Figure 2.2. Screenshot of movie trailer and trailer review input box in the keystroke condition.

Procedure and measurement

Measurement instruments

After reviewing four movie trailers, participants answered questions on their experience and feelings about their online partner:

1. **Social Connectedness Questionnaire (SCQ)**: a subset of 11 items from the original 26-item scale (Table 2.1; van Bel, et al., 2009) was used. Items that referred to a long-term relationship or that related to sharing experiences were excluded.
2. **Liking scale**: all four items (Table 2.2; Pinel, Long, Laundau, Stanley, & Pyszczynski, 2006) which assess the extent to which participants liked their online partner.
3. **Inclusion of Other in Self-scale (IOS)**: a visual scale that indicates the experience of closeness of an individual with respect to another (Figure 2.3; Aron, Aron, & Smollan, 1992).

Table 2.1 SCQ-scale (van Bel et al., 2009).

1. I feel "together" with *x*
2. I often think of *x*
3. I am aware of my relationship with *x*
4. My relationship with *x* feels superficial
5. I feel I have a lot in common with *x*
6. I feel *x* understands me well
7. I feel *x* often thinks of me
8. I know what *x* feels
9. I feel *x* and I are on the same wavelength
10. I feel connected to *x*
11. I get little satisfaction from contact with *x*

Table 2.2 Liking-scale (Pinel et al., 2006).

1. I like *x*
2. I feel close to *x*
3. I would like to meet *x*
4. I feel *x* is just like me

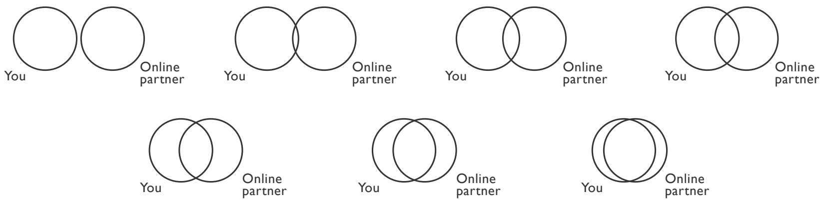


Figure 2.3. The IOS-Scale (Aron, Aron, & Smollan, 1992).

Participants

The participant pool was formed by students from an undergraduate course at Stanford University. They were granted course credit for participation. 80 participants were randomly drawn from the subject pool. The participants were balanced across conditions.

Procedure

The study consisted of four parts:

1. **Ranking of movie trailers.** To create a (seeming) common experience, participants ranked the four movie trailers and saw the ranking of their online partner.
2. **Review of movie trailers.** Participants then sequentially reviewed the four different movie trailers.
3. **Responding to scales.** Participants filled out a questionnaire that included the IOS, SCQ and Liking scales.
4. **Feedback on partner's reviews.** The participants rated their (simulated) partner's reviews with respect to thoughtfulness, quality, complexity and influence.

To maintain confederate credibility, the following strategy was adopted. First, the participants visited a 'waiting room'-page in which they remained until the system

Table 2.3. Results of principle components analysis for the SCQ scale. Factor loadings < .3 are omitted.

SCQ item	1	2	3
1.	**.831**		
2.	**.772**	**.413**	
3.	**.706**	**.470**	
4.		**.640**	.485
5.	**.820**		
6.	**.863**		
7.	**.829**		
8.	**.757**		
9.	**.852**		
10.	**.862**		
11.	**.350**		
% Variance	56.2	11.1	9.4
Eigenvalue	6.18	1.23	1.03
Cronbach's α	.890	.504	-

Table 2.4. Results of principle components analysis for the Liking scale.

Liking scale item	1
1.	**.709**
2.	**.761**
3.	**.859**
4.	**.804**
% Variance	61.6
Eigenvalue	2.47
Cronbach's α	.779

found an appropriate partner. Second, before starting the reviewing task, participants were asked to rank the four movies based on the official movie description. The ranking of their partner always showed the 1st and 3rd movie on the same rank, stimulating a sense of similarity. Finally, for two out of the four movie trailers, participants were told that their partner was not yet finished writing, and that they had to wait 10-30 seconds for their partner to finish.

Results

Before analyzing condition effects on the scales, the structure and reliability of the reduced SCQ and Liking scale were assessed. A principal component analysis (was conducted on the SCQ results, resulting in one main factor explaining 56,2% of the variance (Cronbach's α <.89), and two smaller factors explaining an additional 11.1% and 9.4% respectively (Table 2.3). The decision was made to focus on the first component, which corresponded strongly with the original SCQ scale, while the second and third factor were marginal, and had low internal reliability under the construct (Cronbach's α <.51). Items 4 and 11 were removed from further analysis as they had low loadings on the first component, these happened to be items that were inversely phrased in the experiment. The remaining 9 items were reduced to a single index, capturing the primary component, with high intercorrelations between test items and reliability (Cronbach's α >.92).

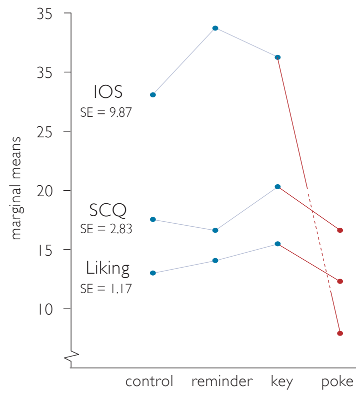


Figure 2.4. Marginal means for SCQ, Liking and (transformed) IOS, per condition.

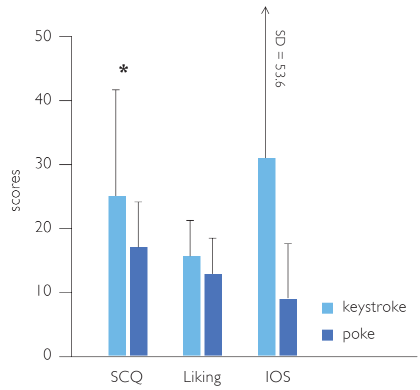


Figure 2.5. Scores and significance for SCQ, Liking and (transformed) IOS scores for *Keystroke* and *Poke*.

The items of the Liking scale loaded on one component explaining 61.6% of the variance. The scale had high internal reliability (Cronbach's α >.77) and it was reduced to a single index, to be used in further analysis.

No condition effect was found on the SCQ-index (F[3,76]=.96, p=.42), the Liking-index (F[3,76]=.87, p=.46), and the IOS scale (F[3,76]=1.31, p=.28). However, when examining the profile plots of the estimated marginal means of the scores on the SCQ-index, Liking and IOS scales, a particular difference was observed between the keystroke and poking conditions. For all scales, scores were higher in the keystroke condition (Figure 2.4).

A follow-up MANOVA was conducted with only the keystroke and poking condition. This exposed a significant effect of condition (poke vs. keystroke) on the SCQ index at F[1,36]=3.97, p=.05, such that the keystroke condition elicited more connectedness. A trend was found for the IOS (F[1,36]=3.30, p=.077); no trends or significance difference was found between *Keystroke* and *Poke* on the Liking index. The keystroke condition tended to elicit more feelings of closeness when compared to the poke condition, but this did not reach significance (Figure 2.5).

Discussion and conclusions

The experiment on sharing online experiences indicates that awareness cues (awareness of keystrokes) fostered more feelings of connectedness, in addition to trends of closeness, compared to the phatic cues (poking). This is contrary to the initial expectations of the study.

In line with research that finds that similarity increases liking (Short et al., 1976), it seems that the keystroke condition supported feelings of similarity; participants were reminded that the online partner was typing, "just like them". Poking, however, may have been considered a 'cheap' message, or an easy and insincere way to communicate, meaning relatively little from an online person with no previous relationship. In line with the importance of sincerity in communication (Beniger, 1987), the absence of perceived sincerity in the poking condition may explain the negative effects on the social experience. One design implication is that mechanisms supporting non-intentional awareness have more impact compared to direct ways of connecting.

An important trade-off in this experiment concerns the control of variables. In the experiment, an online confederate is used for several reasons: participants were presented with comparable social displays (i.e. the icons blinked the same number of times), and participants had the exact same relationship with the online partner—a stranger with a few characteristics similar to themselves. With this design, it was ensured that participants were shown the same subtle social cues (blinks of the icon) based on equal, relatively anonymous, relationships. This experimental design is powerful because it enables us to isolate the causal relationship between social cues and feelings of connectedness.

While the setup with almost-anonymous confederate partners provided powerful experimental control, this anonymity is also a limitation. People in close relationships may perceive phatic cues as more meaningful as compared to near-strangers. For instance, in a close relationship, people may be better able to attribute meaning to phatic cues, as they are aware of socio-contextual information, such as the other's mood, personal situation and activities. Although no quantitative data is available, previous research has also suggested that there are cases in which phatic cues have a positive effect on the experience of connectedness between close ones (Vetere et al., 2009). From a user-system interaction point of view, the richness and aesthetic of the cue may be of importance in how a phatic cue is perceived, as richer and tangible interaction may be considered more emotionally meaningful.

In summary, the presented study found that an increase in intention in subtle social interactions is not necessarily positive: the phatic activity of poking and being poked fostered less closeness, connectedness and liking than unintentional awareness of online activity. Indications of indirect behavior are meaningful, and do more than simply remind a person of the online partner's existence. However, in the current setup, it is likely that the anonymity of the participants towards the confederate negatively impacted the influence of phatic communication. In particular, participants were not able to attribute meaning to the cues they received, as they lacked socio-contextual background knowledge. These insights form valuable knowledge for the design of mediated communication systems and applications. The degree of existing relationships in relation to various levels of closeness, should be taken into account when designing awareness and phatic cues.

3 Design explorations

This chapter describes the design and prototyping activities that were conducted leading to the development of a prototype social awareness system termed Snow-Globe. SnowGlobe is a research probe, created in order to better understand the development of social awareness systems. A design brief was developed based on theory and related work from Chapter 1 and 2. Accordingly, in a research-through-design process, several experiential prototypes were built as design explorations. These were used to grasp the complexity of the design problem with all its constraints, and to develop insights for a final design. Based on the insights and inspired by the explorations, a final prototype system was built. The design process that led to SnowGlobe is outlined and a detailed description of the technical implementation is sketched. The strengths and limitations are discussed in the final section. Results of field studies using SnowGlobe are reported in Chapter 4.

Introduction

Social awareness systems may support people's social connectedness by communicating social information between people. The results in Chapter 2 suggested that subtle social cues may have a positive effect on connectedness. This seemed to be primarily the case for awareness cues, rather than phatic cues, in a context where users were not relatives or friends. Previous work has however suggested that phatic cues indeed may have an effect on the experience of social connectedness, in the case of close relatives in a real-life context (Vetere, Gibbs, Kjeldskov, Howard, Mueller, Pedell, Mecoles, & Bunyan, 2005).

In order to better understand the role of awareness and phatic communication in stimulating social connectedness, a prototype system was designed, implemented and evaluated. With this system, it should be possible to communicate both phatic and awareness cues between users. Contrary to the setup in Chapter 2,

Table 3.1. The focus of the design explorations, related to the framework presented in the previous chapter.

AWARENESS CUES non-intentional	PHATIC CUES intentional	
Awareness Display **Digital Family Portrait** **Solar Display** **Portholes** **CareNet** Media Spaces Daily Activity Diarist **Whereabouts Clock**	**Virtual Intimate Object** **ASTRA** **The Cube** Photomirror	SCREEN BASED
Gust Bowl Focus of design explorations	Feather, Scent, Shaker Lampshade Hug-at-a-Distance Lumitouch	TANGIBLE

the system would eventually be deployed in a field context between two relatives or friends, as to simulate a situation that was as realistic as possible.

In a longitudinal field study with the prototype the effect of similar social cues will be explored. In our system, these cues are implemented in a tangible way that fits the in-home context. Tangible systems have been found to positively influence intimate communication between people, and more emotionally meaningful when compared to screen-based systems (Rittenbruch & McEwan, 2009). The design and implementation of the prototype system, called SnowGlobe, are described in this chapter; the subsequent evaluation is described in Chapter 4.

Examples of tangible awareness systems include, Feather, Scent and Shaker (Strong & Gaver, 1996) and Hug-at-a-Distance (Müller et al., 2005), however these systems have not been formally evaluated. Those social awareness systems that that have been evaluated in a formal setting are mainly screen-based systems, such as ASTRA (Romero et al., 2007) and VIO (Kaye, 2006). The importance of longitudinal studies is recognized in the research described above, but given the lack of such studies, there seems to be a challenge in building systems that can be used as research tools in such a context.

The design goal outlined in this chapter is to create a tangible social awareness system that can be used to study the effect of awareness cues on social connectedness. The system functionalities should enable users to communicate both awareness and phatic cues (Table 3.1). In addition the final system should be understandable for users, it should be robust so it can operate in field conditions for

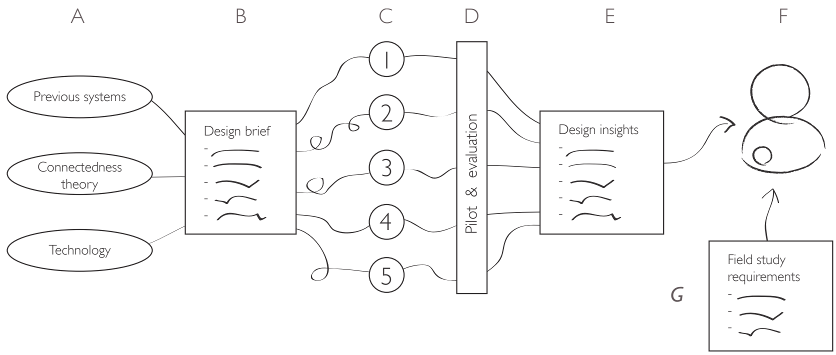


Figure 3.1. Outline of the Empirical Research through Design process followed in this chapter.

several weeks without researcher intervention, and it should fit in the users' homes and routines in terms of aesthetics and interactions.

The design process used for the prototype system is based on the research through design cycle (Zimmerman, Forlizzi, & Evenson, 2007). The adapted cycle, called Empirical Research through Design (Keyson & Bruns Alonso, 2009), was adopted as it further details how design iterations can be used to develop stimulus material for a field study. As social awareness systems are not yet part of our daily lives. First, design explorations should help to understand what potential form, interactions, and communication could be used in a prototype for field study.

Figure 3.1 outlines the process in which the final prototype was developed in this chapter. First, based on literature, available technology and theory on social connectedness (A), a design brief (B) is formulated. Then, designs are made (C) to identify key parameters in the design of (in this case) a social awareness system. Based on informal user evaluations (D) the key insights are identified (E), such as form and interaction types. These insights, together with requirements specific to the nature of longitudinal field studies (G), are implemented in a design iteration in which the final design is built into a prototype that can be used in a contextual field study (F).

This procedure enables a quick exploration of the design space, resulting in a list of possible solutions and interactions. The approach of leveraging design exercises to explore the design space (C) has an advantages over relying on a review of related work only: the explorations are aimed at the design space specific to the current research goal, in terms of context of use, user groups, use-cases and experience-concepts under study. Note that the approach followed was not aimed exploring the full design space of Awareness Systems (i.e. screen based systems, audio based systems, etc., were kept out of the scope of the design activity). The focus was kept on the design aspects relevant for the research goal. Designers explore both underlying theory (on awareness systems and social connectedness) and the dynamics of the user context. This process enables the convergence of theoretical concepts and designed interaction to an interactive prototype.

Design explorations – Five concepts

Four design teams conducted the first design iteration, each consisting of four post-graduate students from a semester course on *Interactive Technology Design*[1] (van der Helm, 2012). Additionally one student took on the task as part of her graduation work, bringing the total to five design projects. Both types of activity were part of a Master program on Industrial Design Engineering.

The five systems were evaluated in an open-house exhibition, with about 40-60 visitors per system. The visitors were able to experience working prototypes of the designs, and they were informally interviewed about their experiences.

Design brief

The designers were instructed to design and build a working prototype of a social awareness system. Students were provided with background knowledge on social well-being and social connectedness. The designers were instructed to follow the instructions as below in their design activities:

1. **Seniors and close relatives.** They were asked to focus on designing for seniors and their close relatives. Providing the design teams with a similar use-case enabled a fair comparison of the designed prototypes.
2. **Tangible interaction.** To adhere to the meta research goal, it should use elements of tangible interaction, rather than (touch)screen-based paradigms.
3. **Intentional/non-intentional.** The design should explore awareness and/or phatic cues. The designers were asked to refrain from focusing on systems that explored ways of communication

As background information students were provided with an overview of related work as provided in Chapter 1. In addition, they were provided with the following literature, to inform them on what the experience of social well-being and connectedness embodies: Ullmer, & Ishii, 2000; Rettie, 2003; van Bel, IJsselsteijn, & de Kort, 2008; Vetere, Smith, & Gibbs, 2009.

Designed concepts

Below, the five prototypes are described and the feedback from the informal open-house evaluation is presented.

WeDo

The first exploration considers an awareness system that connects two homes, called *WeDo* (Figure 3.2). One box would be installed in the senior's home, and the other one in the home of the relative or friend. Motion detection is used to collect presence information, which is displayed in the remote box by the small crack in the opening lighting up. When opening the box, one can see more about the

1. WallTree was part of the same course, but designed after SnowGlobe was developed. It was included nonetheless as it helps to understand particular design principles.

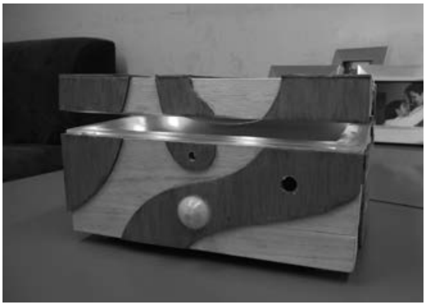


Figure 3.2. The WeDo prototype.

Figure 3.3. The KeyPing prototype.

intensity of the movement (by softly or violently moving Styrofoam balls) as well as hear snippets of sounds from grandparents' living room. Users would not have any way to intentionally communicate with the other box.

The box used a passive infrared 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. Also, it simplified building the prototypes, as input and output were co-located.

Users expressed they experienced the sense of "*…as if (s)he is here with me,*" both through the live and analogue display of presence through the small opening, and through the intimacy of the design, as stimulating in 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. They also appreciated the aesthetic quality of movement being displayed by physically moving objects inside.

KeyPing

The second team closely linked the interaction to a homecoming ritual (inspired by 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 3.3). 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, the grandson can nudge his grandparent by clicking the token representing them to make the token representing him light up brightly on his grandparents' board.

Prospective users perceived the phatic action of 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.

Figure 3.4. The ScatteredConnected prototype.

Figure 3.5. The WallTree prototype.

Cocoon

Instead of adhering to the tangible design guideline, the third team focused on using audio to indicate when a grandparent would be in the same room as the grandchild. For example, when the grandson would be making dinner in his kitchen, and grandmother would enter her own kitchen to get something to drink she could hear a particular sound that was 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 user understanding.

ScatteredConnected

The ScatteredConnected prototype (Figure 3.4) is a collection of photo frames, each representing another close relative. Analogue motion detectors in the room measure the amount of activity of a relative. As a means of non-intentional communication, increased activity will cause the photo frame of that relative in the user's home to light up more intensely. Users can also wave at their photo frame wall from close by, and the photo frame representing them on the wall of their relatives will blink shortly, allowing for a way of intentional social awareness.

The design aims to form a community of users, in which every user has photo frames on the wall that each links to another user, connecting a small group of close friends. In this way, the lighting up of the photo frames creates a light pattern on the wall, showing the network activity and routines of relatives. Users may also wave at the photo frames to make their own picture blink in the room of their relatives.

Users particularly appreciated the low threshold of use, and the combination of intentional and non-intentional communication. As a drawback, the use of multiple devices and detached sensors made installing the prototype a complex procedure.

WallTree

WallTree supports network awareness of up to eight relatives. The prototype is an interactive wall decoration of a tree (Figure 3.5). One branch of the tree represents

Table 3.2. System features of five concepts.

concept	form	# of users	awareness cue	phatic cue
WeDo	treasure box	1-on-1	movement display by intensity of light	none
KeyPing	magnetic token board	± 8	presence display when inserting keys	clicking a token
Cocoon	sound (no shape)	1-on-1	a sound when being in the same room	none
Scattered Connected	picture frames	± 5	movement display by intensity of light	waving at the frames
WallTree	wall decoration	± 10	none	stroking the branches

the user's own home, and each of the other branches represents a close relative that also has WallTree installed. A user can stroke a branch, to light their branch on the WallTree of a relative, similar to the phatic cues of the KeyPing design (one-to-one communication. In addition stroking the personal branch, the users can make their own branch light up in the homes of all the relatives (one-to-many communication).

The aesthetics of the prototype was appreciated, as well as the tangible ways of interaction; stroking was considered an affectionate action.

Design insights

The five prototypes developed in the design project explored different forms, different amount of user networks and different types of intentional and non-intentional communication. Table 3.2 provides an overview of how these aspects were implemented in the five prototypes, and accordingly, general observations with regard to user intention, tangibility, information presentation and field study feasibility.

Awareness and phatic cues

The evaluations of the designs indicated that a combination of awareness and phatic cues is important. In particular, KeyPing and Scattered Connected were successful in combining these two communication principles. On the other hand, although aesthetically pleasing and emotionally meaningful, WallTree always required active user participation.

Types of tangibility solutions

A primary observation was that the approach to refrain from using screens or key-interfaces seemed successful in making the designs blend with the home context; the systems were designed as decorative elements for the living room. In terms of tangible interaction types, users experienced pressing a personal token (KeyPing), stroking (WallTree), and opening the box when using WeDo, were considered meaningful interactions for supporting intimate communication. Waving (Scattered Connected) was considered more abstract, as it was unclear when the gesture was detected by the system.

Information presentation

The abstract displays were found to work well in both the WeDo and WallTree prototypes. These types of display maintained a sense of privacy, as no detailed information of user behavior was communicated. Moreover, contrary to what was expected, users suggested that an abstract presentation of awareness information might support connectedness more, as it stimulates them to imagine what is going on in the other location, thus thinking more of the other. In the case of WeDo, the link between the data collected by sensors (movement) and how it was displayed (movement of Styrofoam balls) was appreciated, as it made the meaning of the display clearer.

Feasibility in longitudinal study

For a prototype that is to be used in a field study, it is important that the system is robust, easy to setup and easy to maintain. The co-location of sensors and display, as demonstrated by WeDo, KeyPing and WallTree, are most appropriate for such a setting; only one device would have to be setup per household. In addition, even though most users indicated they would probably not experience privacy problems, it is important that a user can mask or blur the system, whenever there is a need or desire not to be monitored.

Most design explorations focused on a networked setup with multiple users. However, for sake of simplicity of a field setup, the final system should focus on one-on-one communication. In this way, it is possible to investigate the effects of the system with a limited number of prototypes, and without having to recruit large groups of relatives or friends.

Design exploration – The design of SnowGlobe

After the initial design explorations, a prototype social awareness system was designed as a research probe for longitudinal field studies. In preparing a field study, the focus was on a house-to-house awareness system for sake of simplicity of the setup. In the research probe, the following functionalities for subtle communication were implemented (Table 3.3).

SnowGlobe properties

During a brainstorm session following the design explorations, a snow globe was coined as a metaphor for the system, to visualize the tangible, physical and visual qualities of a real snow globe. SnowGlobe was designed as a social awareness system that blends in the living room interior as a

Table 3.3. Subtle communication provided by the final system.

Envisioned function	Implementation
1. Abstract display of movement as social awareness cue.	Prototype measures movement, and displays by light and some kind of physical movement.
2. Shaking the device (nudging) as means of phatic communication should be provided.	A physical expression of shaking, touching or stroking the devices enables an intentional communication cue at the other user's end.

lamp (Figure 3.6). It embeds the system features in Table 3.3 in the following ways: 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 (awareness cue). One can nudge the other person; by shaking ones globe, the other person's SnowGlobe will light up brightly in orange for ten seconds, and the snow flakes will move around heavily (phatic cue). In the current versions, the sensitivity of the sensor and the colors related to the two functions are fixed, based on what several consulted end-users found both aesthetically pleasing and distinctive. Figure 3.6 shows that sensors and display are contained in one device.

Although not being the core of the research study, the users' privacy needs were considered, given the nature of the study and being a field investigation in a real-world setting. (Boyle & Greenberg, 2005) and (Hancock, Birnholtz, Bazarova, Guillory, Perlin, & Amos, 2009) coined the strategies *blur* and *content control*. Applying blur entails intentionally increasing the vagueness of the information displayed by decreasing the display fidelity, whereas content control enables the user to decide what is communicated over the medium.

The blur-strategy is implicitly addressed by the abstractness of the display. 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 the 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).

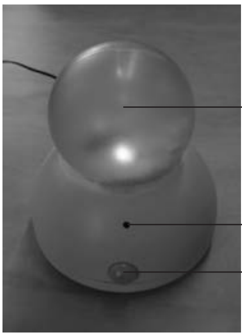


Figure 3.6. The SnowGlobe prototype includes sensors and a display.

Technical Implementation

The design of this system should not only consider the findings on user-system interaction and aesthetics described in the previous section. In addition, it should also consider several practical issues that are important when the system is to be part of people's daily lives (Visser, Vastenburg, & Keyson, 2010). The following practical issues were considered in the design of the field study prototype:

- Robustness and reliability. The prototype should be robust enough to operate for >20 days in a row, without researcher involvement.
- Monitoring of the system. For the researchers it should be possible to monitor and check for irregularities of the system, at any time.
- Unobtrusiveness of technology. Users should notice no interruptions using their normal computers or technology in their homes. This means the prototype system should be completely stand-alone.

As shown in Figure 3.6, 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 3.4 provides an approximate of the amount of movement and the display of light in the remote SnowGlobe. A tilt sensor detects when users shake the globe (a *nudge* is sent when shaken longer than one seconds). The various brightness levels are shown in Figure 3.7. 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 computer-fans. The interaction of the prototype is driven by an Arduino microcontroller[1], and it communicates with a client computer using a ZigBee wireless connection[2]. A white polymer casing encloses the prototype technology and sensors. The building process is depicted in Figure 3.8 chronologically.

A schematic overview of the SnowGlobe field setup is shown in Figure 3.9. SnowGlobe is only connected to a power socket, as the data transmission with an Apple MacMini client computer is wireless. The computer runs a Cycling Max/MSP program that provides the TCP/IP Internet connection that is needed to communicate with another SnowGlobe. This setup ensures flexibility and reduces the obtrusiveness of the study. The user only needs to find a power socket, and could change the location of the SnowGlobe to another place in the home when desired. The MacMini, network switch, and additional cables are installed out of sight. Figure 3.10 shows the

Table 3.4. Overview of activity types measured by the movement sensor of one SnowGlobe versus the resulting brightness of the connected globe in the other location.

Activity type	Brightness
Empty room	0%
Watching TV	25%
Eating breakfast	50%
Walking at 3 meters	75%
Walking close	100%

1. http://www.arduino.cc retrieved 9/9/2012
2. http://www.zigbee.org retrieved 9/9/2012

Figure 3.7. Brightness levels of SnowGlobe increasing from left to right: 0% - 25% - 50% - 75% - 100%.

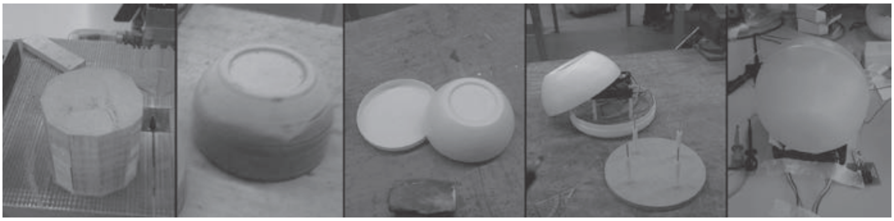


Figure 3.8. Snapshots from the SnowGlobe construction process.

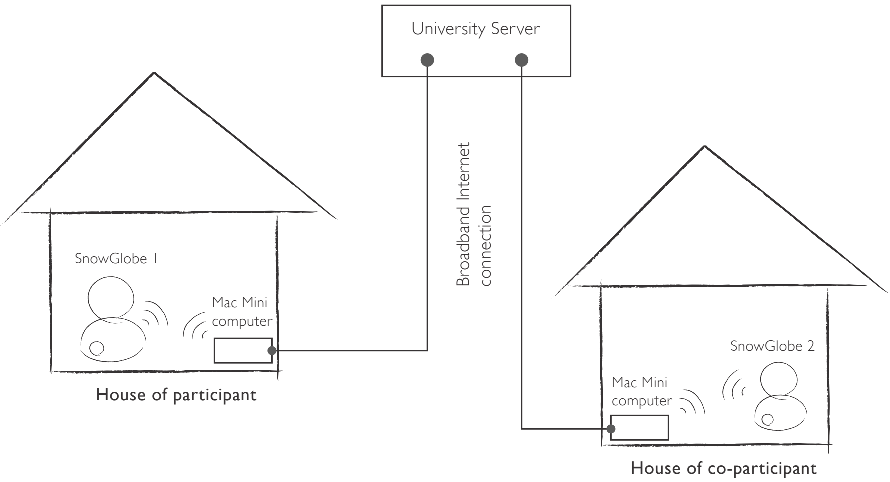


Figure 3.9. Schematic overview of the SnowGlobe field deployment.

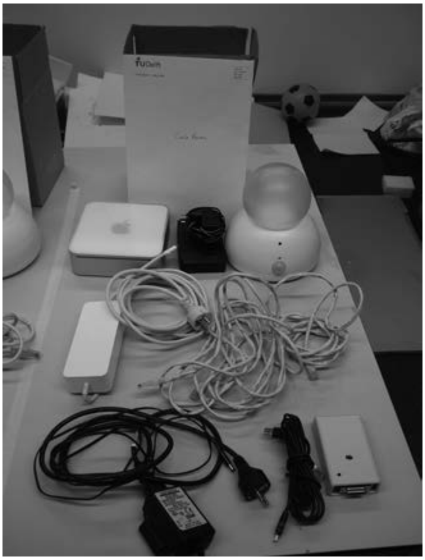


Figure 3.10. Hardware used in SnowGlobe field deployment, including adapters, network switch, Apple Mac Mini computer and SnowGlobe.

hardware needed for a SnowGlobe setup in one home.

When starting up, SnowGlobe connects to a server located at Delft University of Technology. The server then activates the Internet link to the other SnowGlobe. This setup allows the researchers to remotely monitor the system status at any time. To ensure reliability of the connection, broken connections (due to provider or electricity problems) are automatically restored as the client attempts reconnections every 30 seconds. As prototype technology often suffers from instability problems despite thorough testing, a hard-reset function was built in, which 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 for 15 days to test the hardware and software in a live setting. Several automatic reconnects were found (not more than 15 minutes of broken connections) and no hard-resets were needed.

Discussion and conclusions

This chapter presented the design steps and process that lead to the final prototype design of the SnowGlobe awareness system. The design explorations of the various social awareness systems explored different ways of supporting social awareness. Several concepts evolved into interactive prototypes that had a high fidelity in terms of aesthetical appearance and interaction possibilities. Building working prototypes, instead of presenting conceptual designs, enabled potential users to have an experience that is closer to reality. The informal evaluations of the prototypes provided insights into how different forms and interactions were appreciated, and identified the potential of including non-intentional awareness and intentional phatic means of communication. The explorations have also supported the development of a prototypes setup that is robust enough for a longitudinal field setup.

The advantages of the design process followed in developing SnowGlobe, was that the design explorations were explicitly aimed at generating design insights towards building a fully functional field system. The design students were clearly briefed on the desired context, use-cases, materials and experiential concepts, the deliverables provided detailed information on how particular interaction and aesthetical approaches would work. Although purely studying literature on social awareness systems would of also have provided some insights on design and research approaches, the design explorations expanded this by specifically exploring the domain of awareness/phatic communication.

In the current design activities described in this Chapter, it was not the goal to explore the full spectrum of social awareness system, including audio and screen-based systems. In such a case a much less restricted design brief and process should be used. However, in the case when a well-focused research focus is available, and the goal is to develop a design prototype as a tool for research, the Empirical Research through Design is a suitable way of developing relevant design insights.

In concluding, the design explorations resulted in SnowGlobe. The system SnowGlobe is designed as a research tool in a longitudinal field-study context. It incorporates measures for dealing with the challenges of a field context, while at the same time incorporating functions that enable a study into subtle communication cues.

4 Longitudinal effects on social connectedness

Awareness systems can support the experience of social connectedness between close relatives. The previous chapter described the design and implementation of SnowGlobe. As a next step, a field study was set up, to explore how SnowGlobe is used in a natural home context, and to evaluate the effect of its interactions on the users experience of social connectedness. First, an overview of related work is provided, in which an outline is given of measurement instruments that may be used in the field study. Then, the setup for the field study is provided, followed by the results on reported experiences and system use. Also, use routines, and the meanings users have attributed to interactions with SnowGlobe are evaluated. Finally, the value of SnowGlobe for supporting connectedness is discussed, and the measurement instruments used are assessed on their ability to grasping the concept of social connectedness in a field context.

Introduction

Social awareness systems are generally designed 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), Gust-Bowl (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 (also see Chapter 1). The primary goal of the field study as reported in this chapter is to create a deeper understanding on how design and interactions features of an awareness system affect social connectedness. In addition, the aim is to explore how the findings from Chapter 2 hold for a context in which the participants are closely related.

For the study described in the current chapter, the definition for social connectedness was used, as described by van Bel, IJsselsteijn, & 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 (i.e. relationship saliency, closeness, contact quality, knowing each others' experiences, and shared understanding), which can be used to inform the design and evaluation process of an awareness system.

Based on the conceptual understanding of social connectedness, an awareness system (called SnowGlobe) was designed (Chapter 3). 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, the remote device will blink shortly. Through a longitudinal field study, described in this chapter, the effect of user interactions with the system on the dimensions of social connectedness was investigated.

The dimensions of social connectedness were used as the basis for the measurement instruments used in the evaluation. Overall, SnowGlobe was found to have a positive effect on social connectedness by contributing to the dimensions *relationship salience* and *closeness*.

Experiment design

The evaluation aimed to gain insights in the effects of SnowGlobe on two levels:

1. **Effect of use on social connectedness.** The study focuses on how social connectedness was affected by system use. In particular the aim was to understand how particular events of interactions affected the dimensions of social connectedness.

2. **Use and adoption of SnowGlobe.** Another focus is on how the product would be used in a home environment. Also, the aim was to gain understanding of the meaning users attribute to the interactions and display.
   Additionally, the aim was 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 or friends, in their own home environment. Users followed their normal daily living routines whilst participating in the longitudinal field trial.

Measurement instruments

Previous longitudinal research on awareness systems has studied whether users appreciated the functionalities (Keller et al., 2004), how much people use the system (Dey & Guzman, 2006; Keller et al., 2004), whether people experience benefits (Romero et al., 2007). The studies deployed a variety of measurement instruments. Most successful were combinations of interviews and questionnaires, which produced both rich and quantifiable results. Less successful instruments include the use of diaries (Romero et al., 2007) and the day reconstruction method (Khan, Markopoulos, Eggen, IJsselsteijn, & Ruyter, 2008), as these were considered intrusive and time consuming by the participants.

Although an effect on social connectedness, through being in touch, has been presumed by most of these studies, analyses have not focused on measuring this construct. This may be partly due to social connectedness not being the focus of those studies, but it may also be due to the fact that it is complex to measure social connectedness, as it is a subtle and short-term experience (van Bel et al., 2008).

To gain an understanding of the use and experience of SnowGlobe in the present study, a threefold of measurement instruments was deployed: interviews, a log of system use, and daily and weekly questionnaires. The post-trial interviews were held using a general interview guide to maintain consistency in the topics covered, but at the same time allowing 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 SnowGlobe in daily life.
2. **Social connectedness:** 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.

Figure 4.1.The SCQ-5 daily questionnaire calendar.

In an attempt to quantify the effects of SnowGlobe use on connectedness, the SCQ 26-item self-report scale (van Bel, Smolders, IJsselsteijn, & de Kort, 2009) was deployed 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

Table 4.1. Overview of participant couples.

	senior participant		co-participant				
couple	gender	age	gender	age	family[a]	relationship	experiment[b]
1	f	60	f	62	1	friends	6 days
2	f	60	f	64	1	friends	8 days
3	f	63	m	38	2	mother / son	7 days
4	m	63	f	84	0	friends	24 day
5	f	70	f	61	1	friends	41 days
6	m	68	f	42	3	father / daughter	22 days

[a] additional family members living in the house

[b] duration: the number of days in the experimental condition (Figure 4.2)

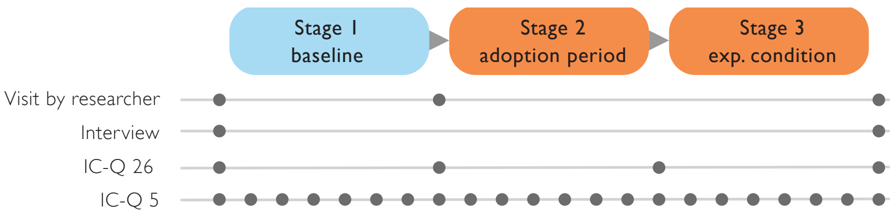
the original scale. The items in this version (SCQ-5) represent the items that were found to load highest on each dimension (van Bel et al., 2009). The SCQ-5 was presented to the participants in a calendar form (Figure 4.1), to remind them to provide responses each day. This approach aimed for increased sampling rate, while minimizing the intrusiveness.

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 with whom they had a close relationship, but who was not living in the same place. Table 4.1 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

Figure 4.2. Schematic overview of stages and measurements during the experiment.



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 4.2), 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 3 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 SCQ-5 was left in the homes of the participant (Figure 4.3).

The second visit took place after Stage 1. The SnowGlobe prototype was installed in the home of the participant. The device was intended to be located in a space that was regularly used by the participant. In all cases, the participants agreed the living room was the most suitable location (Figure 4.3). In subsequent visits, no changes in the position or location of SnowGlobe were observed. Participants were not instructed on how often or in what particular instances SnowGlobe should be used. To reduce the tendency for 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.

Figure 4.3. Two examples of the SnowGlobe in the homes of participants.

The final visit took place, after Stage 3. In 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 SCQ. 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.

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 SCQ and the abbreviated SCQ-5 survey, did not yield significant results when comparing between stages on any of the factors. Moreover, >30% of the SCQ-5 responses were missing. Ideally, these results would have enabled us to identify trends in social connectedness over time. However, the due to a large amount of *in-situ* missing data, and having only six 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 6 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 5 times by Couple 6). In presenting the results, first the focus is 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 4.4 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, participants in Couple 1, 3 (main), and 4 (extended) show long durations of movement for each day. As it is not known whether movement was created intentionally, these data cannot be linked 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 trial periods are shown in Figure 4.5. The data shows that, for couple 5 and 6, the nudging activity seems to stabilize after using SnowGlobe for a longer period of time. This is not the case for couple 4. The

Figure 4.4. Average minutes of activity measured for each participant, in Stage 3.

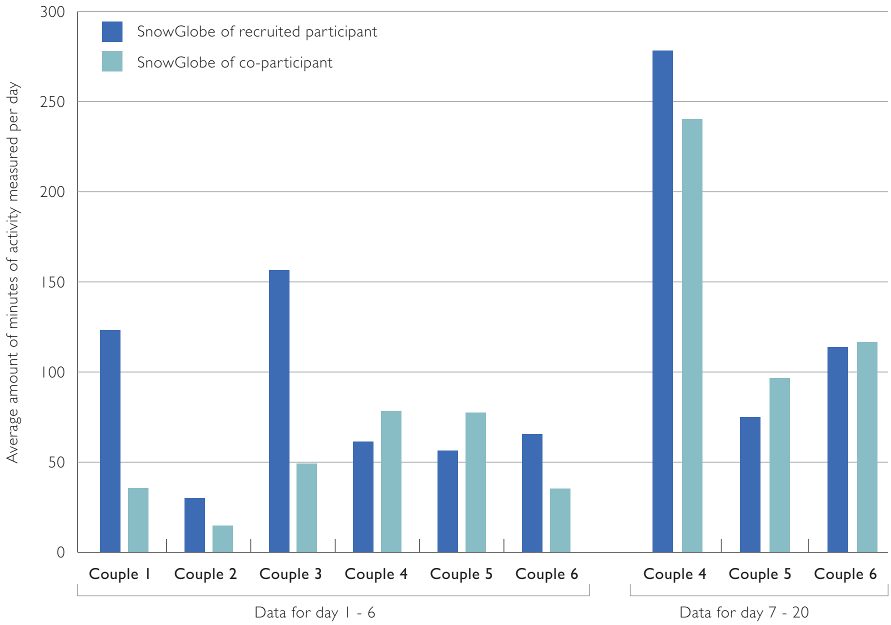
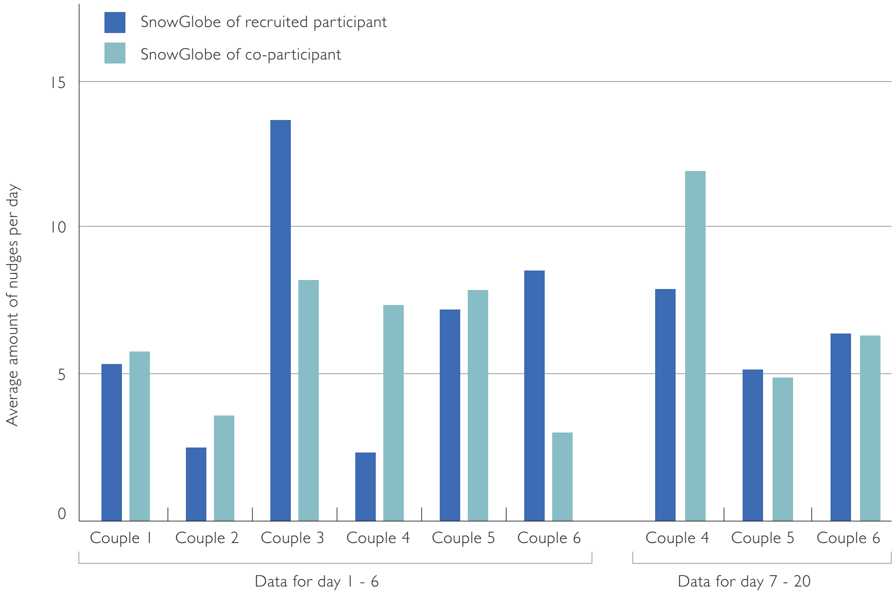


Figure 4.5. Average amount of nudges sent per day for each participant, in Stage 3.



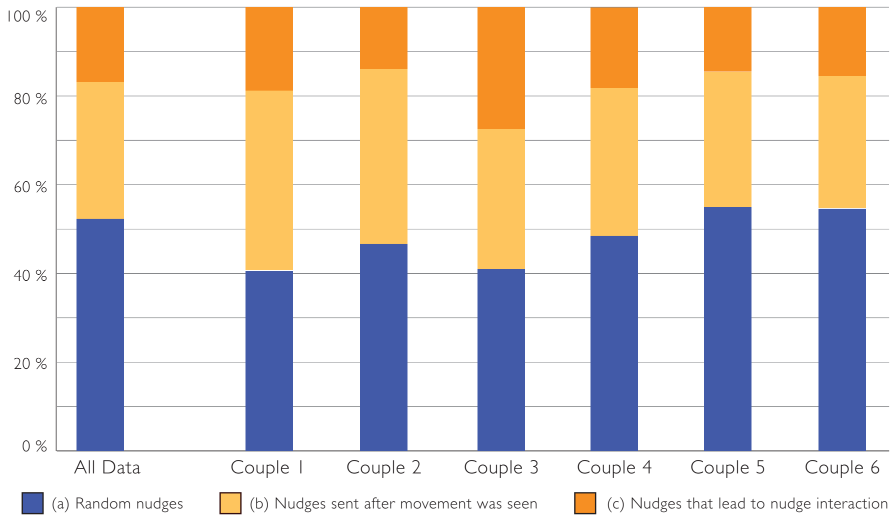


Figure 4.6. Three ways of nudging.

co-participant in indicated that, after a week of use, 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 4.4).

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 replies with a nudge within five minutes. Figure 4.6 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. Figure 4.6 depicts the percentage of each case, as part of the total amount of nudges sent per couple. 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 reported primarily positive experiences in using SnowGlobe, and they mentioned that SnowGlobe positively contributed to their social communication. 11 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, as 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 4.5). 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 of the participants expressed an increased awareness and they reported to think more of the other than before using SnowGlobe. The following quote 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, 8 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. Participants indicated that the triggered conversations on different platforms were not about the device or about their participation in the study.

Interactions and behavior

Participants indicated that they experienced a low threshold in 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.

On seven occasions of use, 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 it was observed 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 and conclusions

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 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.

As expected, these results are not in line with the findings reported in Chapter 2. Although it was not possible to quantify the effect, the results of the interviews and system use, indicate that phatic communication (in terms of nudging) seems to contribute to social connectedness in a real-world context involving close relatives. Most likely, this can be attributed to the fact that participants were well known to each other. Hence, they were better able to form an interpretation of the meaning of the phatic cue. Also, as the study was conducted in the homes of the participants, they were more aware of each other's routines and social context.

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 awareness 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 life, sharing thoughts and experiences. In this way, the awareness system creates a common ground for deeper communication, similar to the way small-talk sets the stage for richer conversations in verbal communication (Schneider, 1988).

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, 5 to 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 in intuitive interaction 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.

Measurement and validity

Quantification of subtle experiential constructs is a challenge. In field-studies, this becomes even more challenging, as there are many confounding events that may trouble collecting reliable self-report data. This is particularly concerning as field studies in the domain of awareness systems usually study a low amount of participants, as the availability of prototypes is limited.

To overcome this problem, in this study a longer-term questionnaire (the ICQ-26) was combined with a shorter daily questionnaire (ICQ-5). However, both appeared to lack sensitivity in terms of measuring the dynamics of the field environment, which may include many potential confounding variables such as social events and visits, which are not related to the intervention. Events such as a birthday party may have a larger impact on social connectedness than the use of SnowGlobe. While the ICQ-5 survey was deployed on a daily basis, it may have been a burden for the participants to accurately fill in a similar questionnaire every day, even though it is less effort than keeping a diary (e.g. Romero et al., 2007). Participants reported that they could not identify changes on a daily basis given the nature and format of the presented questions. These observations indicate a need for instruments that are more tailored to the context of the field, in terms of relevance and intrusiveness.

Another issue concerning field studies is the controllability of the participants' behavior. On one hand, longitudinal field studies are conducted to gain an understanding of certain phenomena in the context of the everyday routines of people, but on the other hand, confounding behavior may influence the reliability of the results (Vastenburg, 2007). In the case of SnowGlobe, participants may, for instance, have talked about their participation in the study, or about the device to one another. Although participants indicated this did not happen, it must be considered as still possible, and affecting the *true* experience of using a social awareness system. The present measurement setup, which combined formal questionnaires with open-ended interviews, was however considered to be the most robust option given current methods. As reported in the next chapter the use of product-embedded experience sampling was used to combine formal measures of connectedness with a non-obtrusive means of data collection.

Design insight

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

- **Subtle cues.** Simple interaction and display, such as motion detection (awareness cue) and nudging (phatic cue), provide users with adequate increase relationship saliency and closeness. Besides having an effect on social connectedness directly, it may also serve as conversation opener 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.

- **Tangibility.** 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.

Conclusions

A challenge in the design and evaluation of awareness systems motivated the development of 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. 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 6 couples of users, for at least 6 days, ranging 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 a need for instruments that, ideally, enable measuring social connectedness shortly after 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, it was possible to identify and understand key interaction features of a social awareness system for supporting connectedness. Although the present study focuses on social awareness systems only, a similar approach may be valid for other forms of computer-mediated communication.

A next step is to develop a measurement methodology and instrument that enables capturing *in-situ* experiences, close to interactions with SnowGlobe. As the present chapter described, the burden imposed on the user in providing self-reports, should be balanced against the researchers' desire to obtain a high sampling rate, and qualitative data on underlying motives of the reports.

5 Design and validation of the Closeness Slider

Measuring user experiences in a longitudinal field study without imposing a burden on participants is a major challenge for researchers. In the field study described in Chapter 4, daily questionnaires were used as a means to investigate experiences over time. However participants indicated that filling them in was a burden, and they found it hard to recollect experiences. This chapter describes the design and validation of an in-situ interactive measurement tool that can collect self-report data on the experience of interpersonal closeness. It addresses the problems above, as it requires low user involvement, and self-report data can be collected close to interaction with the awareness system under study.

First the design of the instrument is described, based on theories from tangible interaction and the Experience Sampling Method. A lab study, as detailed below, was conducted to explore the correlation and sensitivity of slider responses compared to widely used instruments for measuring closeness. Accordingly, a field pilot is described that explores practical application issues of the instrument in a field context, such as response rates, instructions, and types and timing of prompts. The final section of the chapter summarizes the study results, and includes a discussion on the application and limitations of the Closeness Slider in a longitudinal field study.

Introduction

For as long as people have been using technology for communication, researchers and product designers have been interested in how users experience communication products and product concepts. Whereas lab trials have been common practice for several decades, longitudinal field studies are now increasingly considered to be essential for studying social experiences (Rogers, 2011). The advantage of field over lab-context is that users behave more naturally, and the collected results are more ecologically valid (Vastenburg, 2007). However, due to the dynamic and uncontrollable nature of field studies, it can be difficult to measure social user experiences in a reliable way, as a wide-range of factors may influence the collected responses, and social connectedness is a construct that concerns very subtle changes in the experience (van Bel, Smolders, IJsselsteijn, & de Kort, 2009; Visser, Vastenburg, & Keyson, 2011a).

The outcomes of the field study discussed in Chapter 4 identify a key challenge in the measurement of social connectedness. Especially in case of longitudinal studies, where users have to provide their feedback many times, it is important that the participant-effort should be minimized, as to maintain motivation for reporting experiences (Khan, Markopoulos, Eggen, IJsselsteijn, & Ruyter, 2008; Vastenburg & Romero, 2007; Visser et al., 2011b).

Various qualitative instruments have been used and explored in previous longitudinal studies. Diary studies (Rieman, 1993; Romero et al., 2007) have been done to grasp user descriptions of their experiences during the day. The Day Reconstruction Method (Kahneman, Krueger, Schkade, Schwarz, & Stone, 2004) has been used to let participants elaborately reflect each evening on the experiences they had during the day (Khan et al., 2008). Most methods are combined with semi-structured interviews (Metaxas, Metin, Schneider, Markopoulos, & de Ruyter, 2007) to ask any open or remaining questions. Interviews are usually conducted weekly, or in a pre-post-intervention setup, as they tend to be time consuming, and more intense than other qualitative methods. Qualitative methods can generate a deeper understanding of underlying motives. But when higher sampling rates are required to understand daily evolution of experiences, the effort participants have to make imposes a burden on the reporting process.

Quantitative instruments can be reliable instruments for measuring user experience in lab conditions, but are harder to deploy in a field study due to the uncontrollable nature of a real life situation. Quantitative scales have been used with limited success. (Romero et al., 2007)used the Affective Benefits and Costs-questionnaire (ABC-Q) in a pre-post setup to evaluate the attitude towards an awareness system before and after use, and found meaningful results related to the perceived benefits and costs of using the system. (Visser et al., 2011b) have used the Interpersonal Connectedness Questionnaire (SCQ) to understand changes in social connectedness. Neither weekly, nor daily questionnaires were able to discriminate between control and intervention, possibly due to the subtlety of the construct, or the short-term effect of the intervention. (Karapanos, Zimmerman, Forlizzi, & Martens, 2010) have developed the iScale to evaluate user experiences retrospectively. iScale lets users reflect retrospectively on their experiences with a product over a preceding period of time. However, because of the retrospective nature, iScale does not enable an understanding of how user-product interactions in-the-moment affect experiences and behavior.

In designing a longitudinal field study, researchers are faced a dilemma when choosing the optimal measurement instruments. On one hand, they aim to collect data that provides them with meaningful, in-depth, and generalizable knowledge. This often includes elaborate questionnaires or diaries, aiming for high sampling rates to understand developments over time. On the other hand, as participants live their normal lives during the study, the aim is to impose a minimal burden as a result of reporting activity. Methods that demand extensive reports from participants may de-motivate users to keep reporting.

Another challenge faced by researchers is that in most cases, data on user experience is collected some time after the user-system interaction events. In the case of paper questionnaires, it is even impossible to gauge that particular interval. Ideally, participants are asked to report on their experience very close to the event that caused or influenced the experience. This would enable researchers and designers to understand the effect of system behavior on the actual user experience.

The Experience Sampling Method (ESM) was developed to overcome several of the issues above (Hektner, Schmidt, & Csikszenthmihalyi, 2007). ESM prompts participants with multiple short questions during the day. Prompt for responses may be randomly timed, or driven by activity or context detection, and they may request quantitative or qualitative responses. The premise of ESM is to collect data close to the actual experience, with a high sampling rate.

Studies focusing on online social applications have successfully deployed ESM principles to evaluate an online social awareness application (Dey & Guzman, 2006). Modern technology also enables prompts based on user-system interaction patterns, allowing for measurement close to the interactions (Intille, Rondoni, Kukla, Iacono, & Bao, 2003; Vastenburg & Romero, 2007). A problem that persists in most cases in which ESM is applied, is that either users have to spend time on reporting experiences qualitatively, or they have to translate the experience and report on a Likert-scale. Also, in most contemporary ESM-studies, participants needed to carry a dedicated mobile device, or needed to work behind their computer.

A tangible continuous slider instrument was developed as an extension of the ESM. The Closeness Slider was designed to comply with conditions of an in-home field study context, and to make reporting easier and more intuitive for participants. At the same time, it enables to collect data on the experience of closeness, close to user system-interaction. The next section will report on the design decisions and the underlying principles.

Design of the measurement instrument

Several aspects are important for the appropriateness of a measurement instrument in a field context, as discussed in the previous section. Table 5.1 outlines key measurement challenges related to field trials, and the design goals that were formulated to address these issues.

For the design of the measurement instrument, the concept of a slider was adopted. This type of instrument allows discriminating between subtle changes due to its continuous scale, and it has previously successfully been used in studies into emotional experiences.

Table 5.1. Measurement problems and Design goals for a measurement innovation.

Measurement problems	Design goals
Measure the user experience of closeness towards another person.	1. Ground design in existing closeness scales, and validate correlation.
Responses should show how closeness develops over time and after user-system interactions.	2. Flexibility in sample rates, and possibility to connect to any interactive system under study.
Maintaining user motivation for reporting while collecting data at a high sampling rate.	3. Easy to understand and short report times, by using iconic and tangible interaction concepts.

Continuous scales have been widely used for measuring affective experiences during media interaction. For example, sliders have been used in marketing and advertisement research (Stayman & Aaker, 1993), and for evaluating emotional perception of musical sequences (Geringer, Madsen, & Gregory, 2004). More recently, Laurans, Desmet, & Hekkert (2009), have used a force-feedback emotion-slider to evaluate emotional experiences related to images. Lottridge & Chignell (2009) have validated several tangible slider-measurement tools based on emotional responses to short movie clips.

Sliders are found to be particularly appropriate for collecting data close to the actual event creating the experience, and for understanding the changes in user experience over time. Tangible sliders have not yet been used to measure social experiences such as closeness or relatedness. Neither have they been used in a longitudinal field-context, where the interval between responses can be several hours.

The design of the Closeness Slider was inspired by the widely used Inclusion of Other in Self-scale (IOS) (Aron, et al. 1992). This 1-item scale asks users to indicate how close they feel to another person (Figure 2.3). The physical metaphor used for the design of the Closeness Slider was further based on the notion that people easily perceive an inverse relationship between spatial distance between two objects, and the concept of closeness, (Williams & Bargh, 2008).

The Closeness Slider is an iconic, tangible representation of the closeness between the participant and their co-participant in a connectedness-study (Figure 5.1). A blue puppet represents the participant, and a green puppet represents a social contact. Both colors were found to be neutral colors in terms of associated emotions, similar to Lottridge & Masson (2009). When participants move the green puppet closer to the blue one, the participant indicates he or she feels close, and vice versa. The puppet can be moved over a range of 60mm.

The primary motivation for the design of a tangible slider is that, when using the Closeness Slider, participants do not have to mentally translate their experience of closeness to a decimal scale. Instead they report their experience using

Figure 5.1. The Closeness Slider, prompting. The blue puppet (left) represents the participant, the green one (right) their relative.

the physical proximity of two objects. Although the name suggests that the instrument only focuses on the *closeness* factor of social connectedness (van Bel, et al., 2009), the device was designed to correlate with the IOS and SCQ scales. Hence, the name primarily refers to the physical appearance of the device.

On a deployment level, the tangible design has additional advantages over other ESM tools. Users need not to continuously carry a device or access a website. Having an independent device also reduces interference with use of other electronic devices (i.e. smartphones, tablets and computers). A limitation is that participants need to be in the living room to receive prompts, but the advantages are that the intrusiveness of the measurement instrument is reduced.

The black box, on which the puppets are placed, contains a series of blue LED's at the front. These can be turned on by the experiment computer to prompt the participants. While prompting, the LED's will slowly fade on and off, and stop when a response is given, or after a preset amount of minutes (indicating 'no response').

The Closeness Slider is connected to a power socket, and it communicates with an experiment computer using a wireless Zigbee connection. The slider receives a trigger to prompt the user through this connection, from e.g. an experiment-computer. Prompts may be given randomly, at specific times, or at specific events, related to an interactive system or application under study. As such, the Closeness Slider is a tangible single-item scale that can be used in ESM studies.

The physical metaphor for closeness is used to simplify understanding and reporting (goal 3), and the slider can attract user attention whenever feedback is needed (goal 2). Nevertheless these assumptions should be evaluated in a field context. To evaluate whether the Closeness Slider is an alternative for existing scales; i.e. whether the responses correlate with those scales (goal 1) a validation experiment was conducted.

Validation study

The instrument was evaluated for both its perceived meaning (correlation with existing instruments) and its sensitivity (distinguish between social situations).

Setup

In a within-subjects design, participants were asked to envision several different social situations (independent variable), one situation at a time. For each situation, participants were asked to respond to these using both the slider and conventional means for measuring closeness and related constructs (dependent variables).

Participants

Participants were recruited through a university mailing list; 41 participants responded. They were granted a financial reward for participation, being the equivalent of five dollars. The results of 40 participants were used in the analyses. One participant was left out, due to missing data.

Measurement instruments

The slider was compared to three widely used scales, which measure closeness, social connectedness and liking:

1. **IOS – Inclusion of Other in Self** (Aron et al., 1992). This single item requires respondents to indicate how close they feel to another person. They do this by marking one of 7 pictures that show increasingly overlapping circles from 1 to 7, each circle representing one person in the relationship.
2. **SCQ – Interpersonal Connectedness** (van Bel et al., 2009). The SCQ is a 26-item scale. Each item is a statement about the relationship with another person, and for each statement the respondent has to indicate how much he/she agrees, using a 7-point Likert scale. The scale addresses five factors: relationship salience, contact quality, shared understanding, knowing each other's experiences, and feelings of closeness.
3. **Liking** (Pinel, et al., 2006). Respondents indicate how much they agree with each of 5 statement items, on a 7-point Likert-scale. Each statement addresses aspects of how much one likes another person. This scale was included to assess whether the slider only measured closeness, or whether feelings of liking were also included in the response.

Tasks

The participants completed two blocks of computer-based tasks:

1. Participants were asked to think about (A) a *good friend* and (B) a *remote acquaintance*. They used the slider to indicate how close they felt to that person. Additionally, they answered the three scales, introduced above. The order of A and B was randomized and gender balanced between participants.

2. Participants were asked to describe (A) a *positive experience* (e.g. a nice dinner) and (B) a regular experience (e.g. a normal phone call) they had with a good friend. They were asked to rate the situations, using the slider only. The order of the two experiences was randomized.

Whenever participants were asked to respond using the slider, the following text was used as an instruction: *"Please use the slider to indicate how close x".*

Table 5.2. Spearman correlations between slider responses and other scales.

		Closeness Slider	SCQ	IOS	Liking
Closeness Slider	correlation r_s	1.000	.603**	.628**	.251
	sig. (2-tailed)	.	.000	.000	.119
	N	40	40	40	40
SCQ	correlation r_s	.628**	.762**	1.000	.575**
	sig. (2-tailed)	.000	.000	.	.000
	N	40	40	40	40
IOS	correlation r_s	.603**	1.000	.762**	.320*
	sig. (2-tailed)	.000	.	.000	.044
	N	40	40	40	40
Liking	correlation r_s	.251	.320*	.575**	1.000
	sig. (2-tailed)	.119	.044	.000	.
	N	40	40	40	40

** correlation is significant: at the 0.01 level

* correlation is significant: at the 0.05 level

In these instructions *x* was replaced by "…*you feel to [friend/acquaintance].*" (Block 1), or "…*you felt just after that event.*" (Block 2). A picture of the slider with arrows was provided on screen to explain how to indicate closeness. Every time after participants used the slider, they had to return the green puppet to the utmost right position (least close) before continuing.

Procedure

Participants were introduced to the study, and they were not informed about the true goal of the experiment. They performed the experiment tasks in an office cubicle. The cubicle contained a computer screen, a mouse and a prototype of the closeness slider. They were asked to follow the instructions on the computer screen. After performing the tasks, which took approx. 20 minutes, participants were debriefed, and the goals of the experiment were revealed.

Results

A Kolmogorov-Smirnov test indicated significant departure from normality for all variables except the 'neutral respose' ($p< .05$). Therefore, non-parametric analyses were performed.

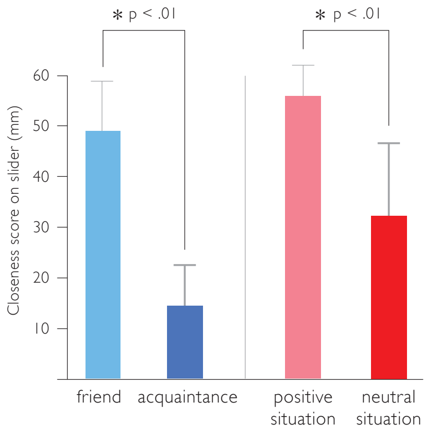


Figure 5.2. Slider scores for each condition (0 = least connected, 60 = close).

Correlation

A one-tailed Spearman correlation test showed a significant relationship between the slider values and the IOS scores (r_s=.63, *p*<.01; Table 5.2). Also, the slider values are significantly correlated with the SCQ index (r_s=.60, *p*<.01). No significant relationship was found between the slider scores and the Liking scale.

Sensitivity

To determine the sensitivity of the closeness slider, we compared (within subject) the measurements for good friends vs. acquaintances, and for neutral and positive situations. A Wilcoxon signed-rank test showed the responses for 'good friends' (Mdn=49.50) and 'acquaintances' (Mdn=13.0) to differ significantly (z=5.51, p<.01, r=.87). The test also showed significant differences between the neutral (Mdn=32.0) and the positive situation (Mdn=60.0), (z=5.20, p<.01, r=.82; Figure 5.2).

Discussion

The results of the validation study show that the slider responses correlate with the IOS and the SCQ scales. No correlation was found with the Liking-scale, which suggests that respondents were more likely to use the slider to indicate feelings of closeness and connectedness, rather than expressing whether they liked the other person.

Significant differences between responses were found when comparing two relationships (*friend* and *acquaintance*), as well as when comparing two social situations within a particular relationship (positive and neutral situation) (Figure 5.3). The latter finding (between social situations) is the most relevant finding for the majority of the field studies in the domain of computer mediated communication, as they investigate the effect of an intervention on one particular relationship. The findings from the study suggest that the Closeness Slider can be used to assess how closeness within a relationship changes through different events and other external effects.

In the present study, the manipulations (situations and keeping a different person in mind) were strong and polarized, as compared to what one might expect to find in a natural field context. This is particularly the case when examining the responses for the *positive situation*, which displays a ceiling effect (Figure 5.3). With the current setup and measurements, it is not possible to quantify the minimal effect size that can be captured by the instrument.

In the tasks given to the participants they were asked to reposition the slider to the most outward position (least close) each time after using it, which was done

Table 5.3. Types of prompts given by the Closeness Slider.

Type	Trigger	Max frequency	Max duration
Timed	Random moments during the day		
Self movement	Local SnowGlobe detects movement		
Remote movement	Remote SnowGlobe detects movement	2 per day	30 min.
Self nudge	Local SnowGlobe is shaken		
Remote nudge	Remote SnowGlobe is shaken		

to minimize order effects. Another, more dynamic, approach is to let users freely move the slider as their experience changes (or when they are prompted), where each response is relative to the previous one (Lottridge & Chignell, 2009). This application may have an effect on the sensitivity of the instrument, as the collected data represents a change-over-time of closeness, rather than an absolute comparison between two situations.

The presented study indicates that the first design goal (comparable with connectedness scales) was achieved. To address the second (sampling frequency) and third (user burden) goals two pilot field studies were performed, as described in the following section.

Field trial pilot study

Longitudinal field trials are subject to less controlled circumstances compared to laboratory conditions. Therefore, before using the Closeness Slider in a full-scale field study the deployment methodology and technical configuration was fine-tuned in two pilot studies.

The primary goals were to evaluate whether the use of the Closeness Slider imposed low burden on the participants, and to explore how a meaningful sampling strategy could be achieved, as to ultimately gain insight in the longitudinal and user system interaction effects on closeness. An additional goal of the pilot studies was to improve instructions given to the participants, to optimize validity of the responses. In both studies, the SnowGlobe awareness system was used as the system under study.

Setup and instructions

The prompts given by the Closeness Slider could be randomly timed, or related to user-product interaction. Table 5.3 provides an overview of the different types of prompts. To reduce complexity of interpretation, we did not include prompts based on sequences of interactions. Prompts lasted for 60 minutes, or until the participants provided a response by moving the puppet on the slider. Additionally, the prompting behavior adhered to the following rules:

- Interaction-related prompts replace any active prompt, and reset the duration of the prompt to 60 minutes.
- Interaction-related responses is labeled with the last triggered interaction prompt-type

In the pilot studies, SnowGlobe was installed at the first day of the trial; the study did not include a control phase, since the focus was only on the measurement instrument, rather than on evaluating the impact of the awareness system on the user experience. At the start of the pilot, participants received the following instructions, both verbally and by e-mail (translated from Dutch):

> *"We would like to understand how close you feel to x [name of co-participant] at different times of the day. At random moments during the day the front of the slider will slowly blink. At those times we ask you to move the green puppet closer or away from the blue puppet to indicate how close you have felt to x in the past hour. After you have moved the puppet, the lights will blink fast a few times to confirm your response."*

The instructions differ from the lab-study in that after reporting, the puppet needs not to be placed back in the middle of the slider. Hence, participants can always see their previous response. This is similar to the approach by Lottridge et al. (2009), although now used with a greater time interval.

Participants were told that, regardless of being prompted, they could move the slider at any time to indicate their closeness. To reduce a tendency to provide socially desirable answers, they were also told that the slider was not connected to any of the SnowGlobes.

Participants and procedure

Two user couples were involved in the pilot study. Couple 1 consisted of two female friends, aged 65-70. Couple 2 was a mother and a son (55 and 28 respectively). Both couples were familiar with using SnowGlobe.

SnowGlobe was installed in the living room, and the closeness slider was installed within sight of the globe (Figure 5.3). Participants received a verbal instruction on how and when

Figure 5.3. Two photographs of an example pilot setup, including the slider and a SnowGlobe.

to use the slider, and the slider was configured to prompt as indicated in Table 5.3. Three days after installation participants were called to check if there were any questions, and to check whether the devices were working properly. Additionally, we checked the status of the system on a daily basis, to prevent any disruptions.

The evaluation was performed by analyzing the slider responses, and by short interviews halfway and at the end of the pilot duration.

Observations and discussion

Response rates and behavior

For both couples, an average of ±1.5 responses per day were collected. The overall response-rate was 19% (all prompts, all participants), and 27% of all responses was related to interaction-triggered prompts.

Response rates at night were much lower than during the day: 10% response (12am - 7am) vs. 38% response (7am - 12am). One participant indicated that she also did not like to be prompted at night, as it could evoke curiosity from passers-by.

Using the current setup, it was not possible to distinguish unanswered prompts on whether the participants did not want to answer, or whether they were not able to respond (e.g. being away from home).

The interaction-trigger 'Self-movement' (Table 5.3) was triggered almost every time when a response was provided, but often it was overruled by other interaction triggers. This is inherent to the fact that SnowGlobe was usually positioned close to the slider. 'Self move' was triggered whenever a participant was around, not suggesting any particular interaction event. Therefore it could be removed from the list of triggers.

Perceived burden and clarity of instructions

The responses provided by one participant (participant 2, couple 1) were not included in the analysis above, as she indicated she moved the slider *"just whenever I feel emotional. I'm an emotional person, so I like moving it up and down."* She indicated she listened to the initial instructions, but she did not review the instructions in the e-mail. She also mentioned she had the impression that the slider was linked to the SnowGlobe of her co-participant, despite that it explicitly mentioned not to be the case. The other three participants indicated instructions were clear, but that re-reading the e-mail with instructions had been necessary.

No problems were expressed in using the slider to indicate their sense of closeness. They indicated the device was easy to use and that they spent around 5-10 seconds per prompt (from seeing it, until the response was confirmed by the device). Two participants indicated they would have been willing to respond to more prompts than they were given in the trial. These observations suggest a low perceived burden as a result of participation in the trial.

Participants indicated they had the feeling that some prompts were directly triggered to SnowGlobe actions, because the prompt came directly after SnowGlobe activity.

Table 5.4. Pilot study insights and improvements for the Closeness Slider field study protocol.

Observations	Methodology improvement
1. Prompts are most useful during day hours: 6am - 12pm.	Random timed and remote prompts will only be given during daytime (6am - 12am). Local interaction prompts will be given anytime.
2. Prompts are easily linked to SnowGlobe interactions by participants.	Random delay (15s-60s) between SnowGlobe interaction and prompt of closeness slider.
3. 60 minute prompt is unnecessarily long.	Prompt duration reduced to 30 minutes.
4. Current prompting frequency does not evoke enough responses per day.	Random timed frequency increased to 5 per day. Prompt duration decreased to 30 minutes.
5. Self-move trigger is not meaningful.	Self-move trigger removed as interaction-trigger.
6. Users cannot cancel a response.	Add cancel-button to the slider design.
7. Clear and easily accessible instructions should be provided.	Instructions will be provided verbally, and additionally on an instruction card and e-mail.

Improvements of methodology

In summary, the pilot studies provided several insights for the development of the measurement procedure, as outlined in Table 5.4. The improvements were implemented in software (1-5), design (6) and instructions (7). The revised instructions were informally validated with four potential participants. The improved measurement instrument and procedure were deployed in a full-scale field study (Chapter 6). The following section will discuss the validity and usefulness of the Closeness Slider, as well as its limitations in a field study context.

General discussion and conclusions

This chapter has reported on the design and validation of the Closeness Slider: a continuous slider as self-report instrument for closeness. The instrument was designed for evaluating the feelings of closeness of communication systems, services and applications, in a longitudinal in-home context. For this context, it was designed to fulfil three goals: 1) responses should correlate with widely used closeness scales, 2) the responses should show how closeness develops over time and how it is related to interactions, and 3) responding should impose a minimal burden on participants.

The lab validation study suggests the first goal was met. The Closeness Slider correlates with the IOS and SCQ scales, but not with the Liking-scale. This additionally suggests that the instrument isolates the user experience of closeness from the feeling of liking another person.

The lab and pilot studies indicate that the second and third goal listed above were not yet fully met. The lab validation demonstrated that the instrument enables distinguishing between very positive and neutral events. At this point it is yet unclear how sensitive the instrument is in terms of capturing small changes in the experience of connectedness, In the field pilot, an average frequency of 1.5 responses per day was collected, with which a general profile of closeness development could have been sketched. The observed responses rate, however, would be insufficient to capture fluctuations during the day, or as a result of product or system use.

Participant reports indicate the burden of reporting with the slider is minimal, and, some participants would be willing to spend more time on reporting. All but one participant indicated the slider was easy to use, but the instructions should be made more easily available for participants. A drawback of the decision to design the instrument as a single-item scale is that it only measures closeness. Nuances on the several factors constructing the connectedness experience (van Bel et al., 2009) are not captured. Therefore, it seems vital to include questions about these factors in a post-trial interview in field studies.

Based on the pilot study, several improvements to the methodology were suggested (Table 5.4). These improvements related primarily to the software implementation, which could be easily adapted for future field study. An implementation of these suggestions may let the measurement instrument and methodology to also fulfil the second and third design goal.

The design and deployment procedure of the Closeness Slider will have some limitations in full-scale field studies. First, the measurement instrument is not mobile, and thus only able to collect responses when the participant is at home. In studies on stationary awareness systems this may not be a problem, but the slider would be less appropriate for evaluating mobile-phone awareness systems, for instance. Second, in a setup similar to the pilot studies, it is impossible to know the exact cause of a change in closeness, as participants are not asked to provide an explanation for their response. In particular responses to randomly timed prompts may be affected by other social events in the life of a participant.

In summary, this chapter presented the design, validation, and field pilot of a novel self-report measurement instrument for interpersonal closeness. Considering the improvements suggested in the discussion, the instrument could be considered a promising tool for understanding both longitudinal and momentary changes in closeness, related to user-system-interaction. The field study presented in Chapter 6 will investigate whether the Closeness Slider enables an assessment of short-term subtle changes in social connectedness experiences.

6 Short-term effects on social connectedness
A second field study with SnowGlobe

This chapter presents the findings of the second field study using SnowGlobe. In the previous field study (Chapter 4), questionnaires were used to measure the effects of SnowGlobe on social connectedness. The present study extends this work by examining the relationship between individual user-system interactions and effects on connectedness. A more thorough understanding of these effects could help designers to develop better communication systems. The Closeness Slider (Chapter 5) was used to develop an understanding of the individual effects of subtle cues.

First, the field study setup is described. Next, the measurement instrument and procedure are described, outlining how the Closeness Slider, interviews and use log data are combined. The results are presented, and novel insights into the effect of awareness cues (display of movement) and phatic cues (nudging with SnowGlobe) are presented in the final section of this chapter.

Introduction

Subtle communication may affect both short and long term feelings of social connectedness. As described in Chapter 1, subtle cues can be created intentionally or non-intentionally, and, in the case of social awareness systems, they are usually presented in the periphery of people's attention. Awareness systems can support subtle communication by providing social awareness and by enabling users to communicate phatic cues (Vetere, et al., 2009). However, only limited empirical evidence exists on the effects such cues have on the everyday experience of social connectedness. A better understanding of these effects could help designers to more effectively develop mediated communication features in products and services.

In the first study using SnowGlobe, a positive effect of system use as a whole on social connectedness was found using qualitative methods (Visser, Vastenburg, & Keyson, 2011). However, no data were collected on how individual interactions affected user experience. Individual effects of non-intentional and intentional communication could not be analyzed.

To understand the effect of individual interactions on user experience, self-report data is ideally collected *in-situ*, close to the actual experience and over longer periods of time (Intille, et al., 2003; Vastenburg & Romero, 2007). These requirements are needed to maintain ecological validity (Rogers, 2011). Existing measurement strategies, such as Experience Sampling (Hektner, et al., 2007), Day Reconstruction Methods (Khan, et al., 2008) or diaries (Romero et al., 2007), do however impose a considerable burden on the participants, ultimately causing participants to stop reporting, or create automated responses. The Closeness Slider was developed to solve this problem (Chapter 5).

A second field experiment was set up to study how much and when the user experience of social connectedness is affected by individual interactions with SnowGlobe. The primary aim of the study was to gain insights on two aspects:

1. The effects of awareness and phatic cues on the experience of social connectedness.

2. The dynamics of that experience at a micro level time, as an effect of using an awareness system.

Four user couples used SnowGlobe for three weeks. Self-report data on their experiences was collected using the Closeness Slider.

Experiment design

Measurement instruments

Closeness Slider

The Closeness Slider was used to collect self-report data on the user experience of social connectedness (van Bel, et al., 2009). This instrument enables frequent sampling, without imposing an obtrusive burden on the participants. Slider prompts were randomly timed, or triggered by user-SnowGlobe interactions. The design of the slider and the accompanying procedures were improved, based on the findings in Table 5.5 (Chapter 5). This included an addition of a 'cancel'-button on the side of the slider, and the prompting procedure as outlined in Table 6.1.

Throughout the longitudinal study, different response rates were expected for each participant, despite all subjects being exposed to the same prompting strategies as indicated in Table 6.1. The participants each had different lifestyles; some were retired, some are working full-time, and one was still a student. To account for the dynamics of the field trial, we set a target minimum of one response per response type in two days. If after the first 5 days this target was not met, the maximum frequency per type would be increased. The configuration was updated from a distance, without the participant noticing it.

Table 6.1. Settings for the prompts given by the Closeness Slider as used in this study.

Type	Trigger	Max frequency	Max duration
Timed	Random moments during the day	5 / 2[a]	30 min.
Remote movement	Remote SnowGlobe detects movement	2	
Self nudge	Local SnowGlobe is shaken	4	
Remote nudge	Remote SnowGlobe is shaken	4	

[a] frequency in two experiment stages: baseline / experiment

Additional measurements

Interviews were held at two moments: a short introductory interview to understand the relationship of the couple and their communication habits (pre-trial), and an extensive interview to evaluate the user experience of social connectedness, and to debrief participants (post-trial). The post-trial interview aimed to gain insights in the user experience, and the experience of social connectedness in particular. In the interview guide the factors from the SCQ (van Bel et al., 2009) were used as topics: closeness, sharing of experiences, wavelength differences, quality of contact and salience of the relationship. The interviews were semi-structured (Patton, 2002), and were recorded for analysis.

In the post-trial session, the data collected via the slider were reported back to the participant who provided them. This was done to probe the participant into reflecting on the responses they had provided, to gain additional insight in the underlying experiences and understand their response behavior.

A log of all user-SnowGlobe interactions was maintained to gain an understanding of when and how often participants used SnowGlobe. This included sent and received nudges, amount of movement measured and whether SnowGlobe was covered or not.

Participants

Four couples were recruited for the field trial. The participants were drafted from the participant database of our institute. Each of the participants was asked to participate together with someone with whom they had a close relationship, but who was not living in the same location. The recruitment criteria were (A) a family relationship with the co-participant, (B) <20 km radius from the research institute, and (C) not being away from home more than 2 connected days during the trial. Education and gender were treated as random variables. Table 6.2 shows the participants who agreed to join the study.

Procedure

For each user couple, the target duration of the trial was four weeks: one week of baseline measurement (Stage 1) and three weeks under the experimental condition (Stage 2) (Figure 6.1). The duration varied slightly per couple, due to the

Table 6.2. Overview of participating subjects.

	Participant A			Participant B				
couple	gender	age	family	gender	age	family	relationship	experiment[a]
1	f	60	1	m	31	1	mother / son	18 days
2	m	65	2	f	62	2	brother / sister	22 days
3	m	65	1	m	32	1	father / son	21 days
4	f	62	2	f	24	1	mother / daughter	19 days

[a] duration: the number of days in the experimental condition (Figure 6.1)

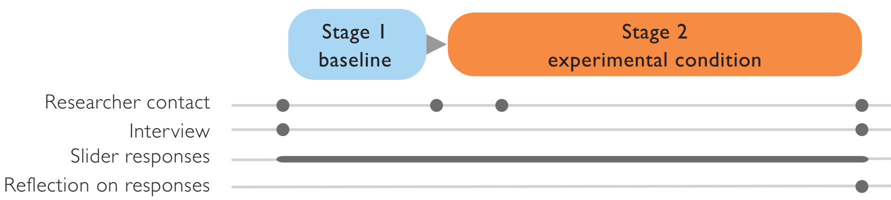
availability of the participants. In Stage 1, participants only had the Closeness Slider installed, which prompted 5 times per day, at random times. In Stage 2, SnowGlobe was also installed and participants were asked to use the system for the remaining 3 weeks of the trial.

In the course of the study, participants were contacted by the researcher on four occasions: 1) a visit before Stage 1, 2) a visit before Stage 2, 3) a phone call 3 days into Stage 2, and 4) a visit at the end of the trial. In the first visit, participants were introduced to the study. The Closeness Slider was installed in the living room, of the participants where the kick-off interview was held. The instructions that were developed in Chapter 5 were provided as an instruction card (Figure 6.2, left).

The second visit took place right before Stage 2. The SnowGlobe prototype was installed in the living room of each participant. The placement of the slider and SnowGlobe were checked before, after and in between stages. Also, participants where asked not to move any of the devices within their house, and they indicated they had not done so. They were not instructed on how often or in what particular instances SnowGlobe should be used. Instead, a second A5-sized instruction card was provided, to remind them about the functionality (Figure 6.2, right). To reduce the tendency for the participants to provide desirable answers, they were told that SnowGlobe was a third-party-produced prototype.

After the first three days of Stage 2, the researcher checked if the participants had used SnowGlobe, and if they had regularly responded to the slider prompts. The three day period was chosen as previous studies with SnowGlobe showed that novelty effects in user-system behavior tended to disappear after 3 days (Visser

Figure 6.1. Schematic overview of stages and measurements during the experiment.



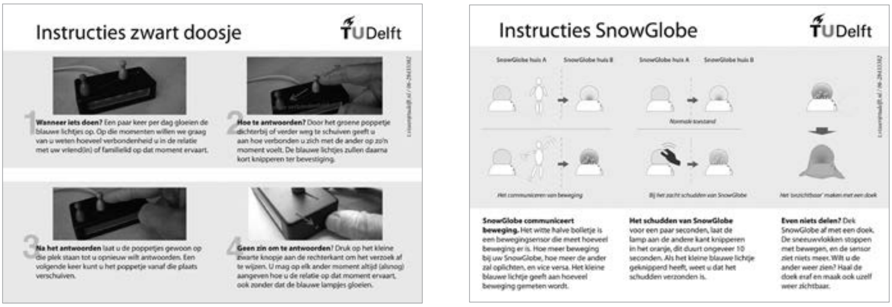


Figure 6.2. Instruction card for the Slider (left) and SnowGlobe (right).

Figure 6.3. The SnowGlobe awareness system (left) and the Closeness Slider (right) in the home of one participant – Couple 3, Jack.

et al., 2011). In a phone call after three days, the researcher informed with the participant whether SnowGlobe and whether they understood the slider prompts. Also, in cases where response rates were low, or variation was low, participants were asked how many responses they provided per day (without suggesting they were low on response rate). When interaction intensity with SnowGlobe was low, the researcher asked whether the participant understood the functionalities, and explained if necessary.

The final visit took place at the end of the trial, after Stage 2. During this visit the exit-interview and reflective interview were held. Finally participants were de-briefed. Participants were told that they could contact the researchers by phone or by e-mail at any time beyond the scheduled visits, whenever problems or questions arose. An example of the field setup is shown in Figure 6.3.

Results

Out of a total of 1119 prompts, 459 responses were collected, 5 prompts were canceled by the participants, and 655 prompts did not lead to any response.

The plots in this section provide a detailed insight into the individual user experiences for each type of prompt. The amount of prompts triggered by interactions with Snowglobe, as well as the response rate for those prompts were expected to be higher. This expectation was based on the pilot study in Chapter 5. For many prompt-types, <10 responses were collected, per participant. Therefore, it was considered inappropriate to study statistical significance. Instead, the data is presented per couple separately in the following sections. For each couple, first a description is given of their individual lifestyles. Then the collected quantitative and qualitative data is presented, followed by an outline of the trends that can be observed.

Couple 1 – Tina and Tom

These are mother and son, living in the same village, 5 km apart. Both have a full time job, in which they use modern communication such as e-mail and Skype. They are in touch once or twice per week, depending on how busy they are. Although they have busy lives, and days pass when they do not think about each other, both consider their bond to be strong, and stated that they feel as though they share the same wavelength. Both Tina and Tom are single and live alone.

Below are illustrative quotes from the interview at the end of the field trial.

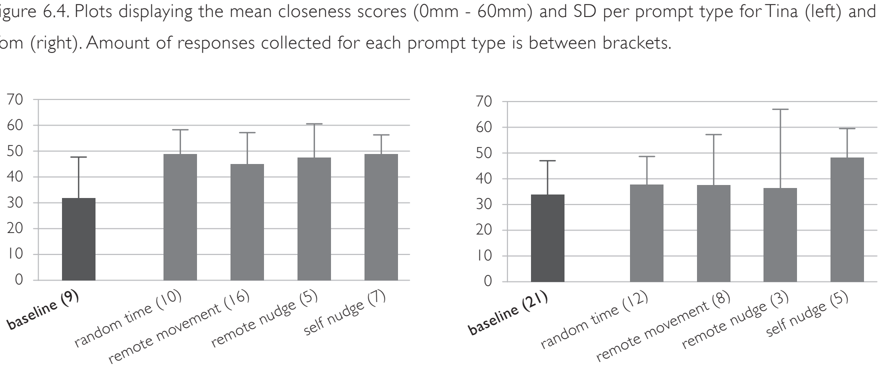
> *"I try not to call him too often during the week, normally… SnowGlobe was a nice way of staying in touch, without having to call or text him." (Tina)*

> *"I think our contact has grown more intense. We were [now] able to say 'Hi' when we got back from work, and sometimes we then called, but sometimes we didn't." (Tom)*

> *"I did not like to move the puppets too far away from each other... it didn't feel right." (Tina)*

An interesting observation for this couple is that Tina notes SnowGlobe to be a good alternative to continuously stay in touch in a more subtle way than more obtrusive media such as sms-text. For her, the introduction of SnowGlobe in her living room indeed seems to have increased her sense of social connectedness (Figure 6.5). For Tom, this is not shown in the slider reports over time, but as he indicated in the interview, creating phatic communication increased his sense of connectedness (Figure 6.4, right). Tina also indicated, related to the measurement

Figure 6.4. Plots displaying the mean closeness scores (0mm - 60mm) and SD per prompt type for Tina (left) and Tom (right). Amount of responses collected for each prompt type is between brackets.



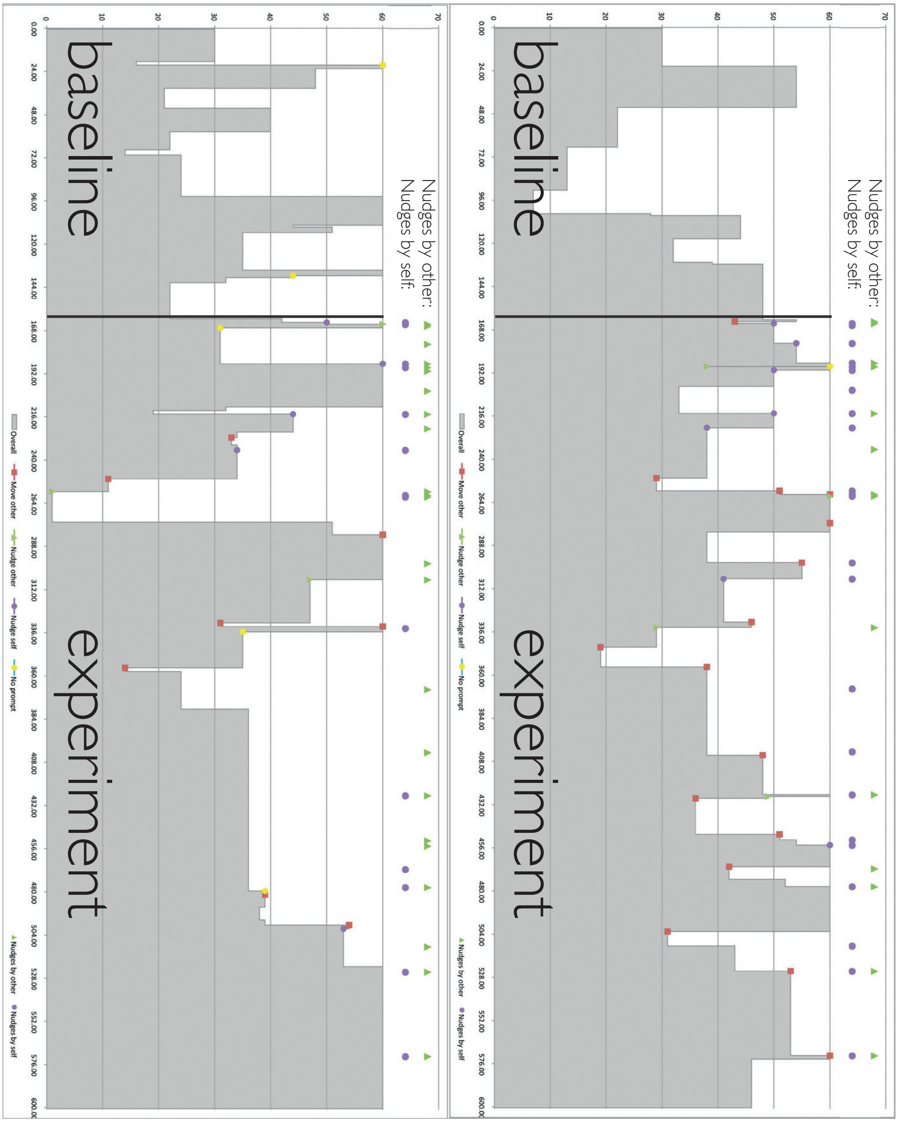


Figure 6.5. Plots of the slider scores over the full duration of the trial, with phatic communication indicated, for Tina (right) and Tom (left).

instrument, that the semantics of the device may have influenced her reporting behavior, i.e., she had a preference for having the puppets close together, which may have influenced her response behavior.

Couple 2 – Kees and Sandra

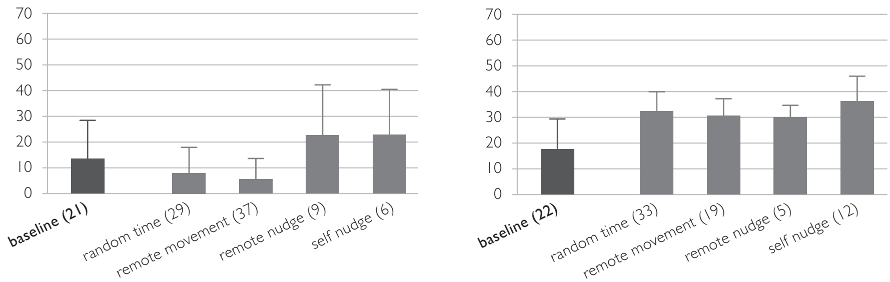
Kees and Sandra are brother and sister. They live ±30 km away from each other and see each other regularly. Both are familiar with modern communication technologies (such as e-mail), but usually they use the telephone to stay in touch. They call each other a few times each month and the initiative for calling is equal on both sides. E-mail is only used for formal communication. Both Kees and Sandra are retired from work, but Kees still works as a semi-voluntary taxi driver for school kids. While they did not express an explicit need for more contact, having more contact was not perceived as a negative factor. Kees and Sandra both have a partner whom they live with.

Below are some illustrative quotes from the exit interview, at the end of the field trial.

> *"[having SnowGlobe] was nice and fun! I was not always paying attention to the device, but you are more aware, and it provides an idea of whether they are there…" (Kees)*
>
> *"For me it sometimes was another way of saying 'good morning'… [break] No, otherwise I probably wouldn't have said that or called him." (Sandra)*
>
> *"I believe your data is correct, but I just cannot remember all the instances or peaks." (Kees).*

Kees and Sandra were both at home much more often than the other participants. This can be seen in their response freqency in Figure 6.7. Sandra in particular valued the phatic communication enabled by SnowGlobe (i.e. 'saying hi'), which is also suported by the amount of phatic cues created by her. Kees' experience was based much more on the awareness functions. Interestingly, the slider reports in Figure 6.6, show that Kees experienced much more connectedness as a result of phatic cues, which may be explained by the fact that he did not exactly remember how his experience developed as the data was shown to him.

Figure 6.6. Plots displaying the mean closeness scores (0 mm - 60 mm) and SD per prompt type for Kees (left) and Sandra (right). Amount of responses collected for each prompt type is between brackets.



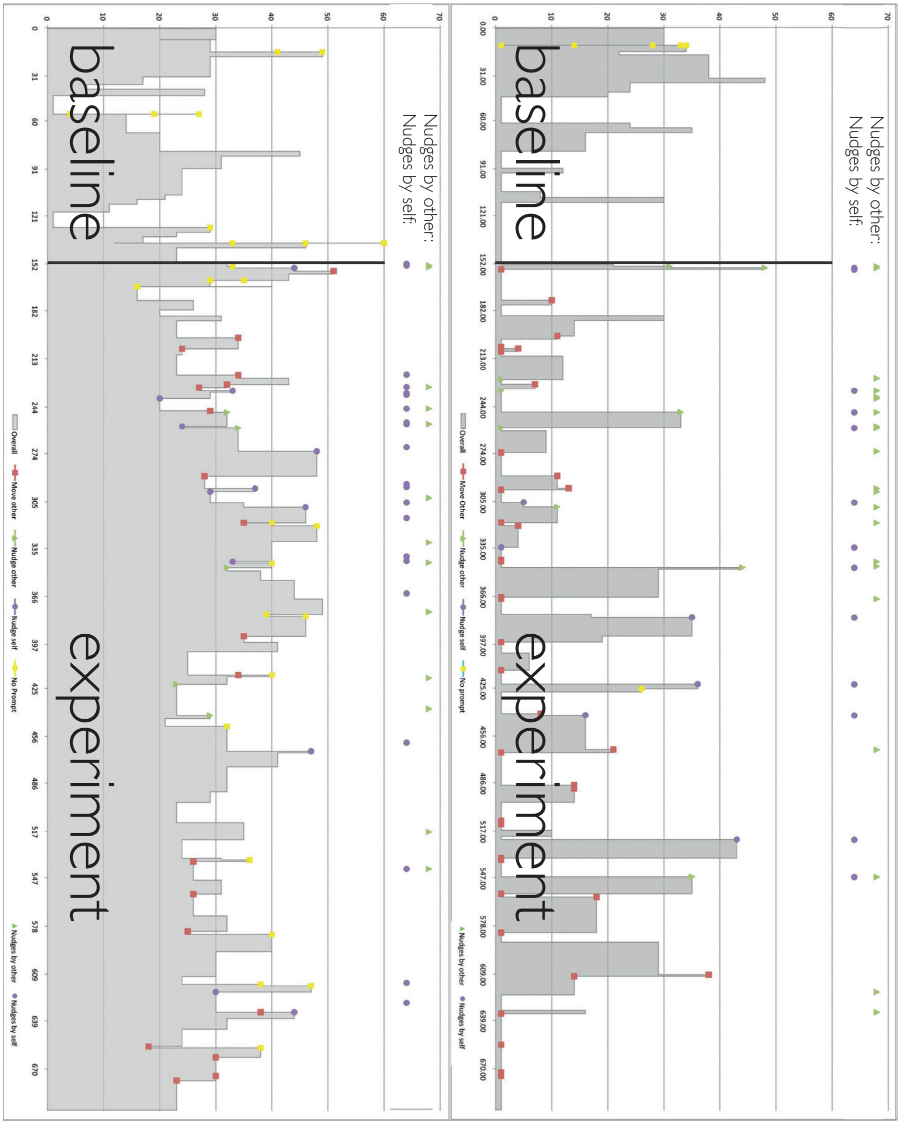


Figure 6.7. Plots of the slider scores over the full duration of the trial, with phatic communication indicated, for Kees (right) and Sonja (left).

Couple 3 – Joseph and Jack

Joseph and Jack are father and son. They live ±40 km away from each other. Joseph is retired and Jack has a job for four days a week. They see each other once a week on average, and besides face-to-face meetings they use texting or e-mail to communicate, as they appreciate the asynchrony of the media in their busy schedules. The telephone is not used often for social interaction. They consider their bond to be strong and they both feel they are on the same wavelength. Both Joseph and Jack have a girlfriend whom they do not live with.

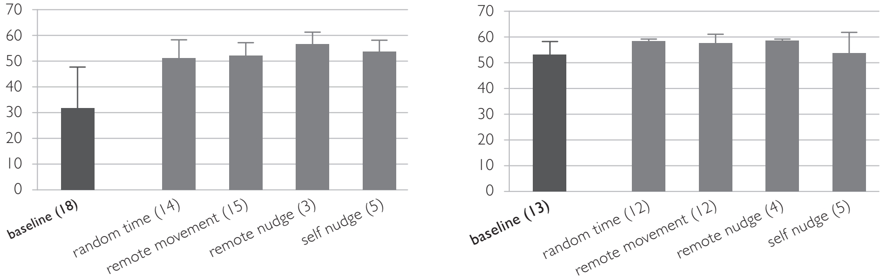
Below are some illustrative quotes from the exit interview, at the end of the field trial.

> *"It made me imagine how his room was and what the device would be like in his place, so, yes, somehow I was thinking about him more often." (Joseph)*

> *"I think often my shaking [i.e. phatic cues] would not arrive… I'm not sure whether the device worked, really. Maybe it's unreliable… it's not so transparent." (Jack)*

The data collected from Joseph and Jack, in terms of various types of interaction (Figure 6.8) does not vary much between types. The difference that can be seen, is that Joseph experienced less connectedness in the baseline-phase, which is also confirmed over time, in Figure 6.9. Joseph mentioned that as he received cues, he would try to understand what Jack was doing and what was going on. This made him think of Jack more. Jack on the other hand, considered SnowGlobe *'interesting',* but he doubted the functioning of SnowGlobe, which could be related to some technical problems at the start of his trial (he accidentally disconnected SnowGlobe for two days). Also, Jack mentioned after a few days of *"experimenting"* with the slider, he decided that he is *"always close to his father"*, so he kept the puppets close together, shown by the ceiling-effect in Figure 6.9.

Figure 6.8. Plots displaying the mean closeness scores (0 mm - 60 mm) and SD per prompt type for Joseph (left) and Jack (right). Amount of responses collected for each prompt type is between brackets.



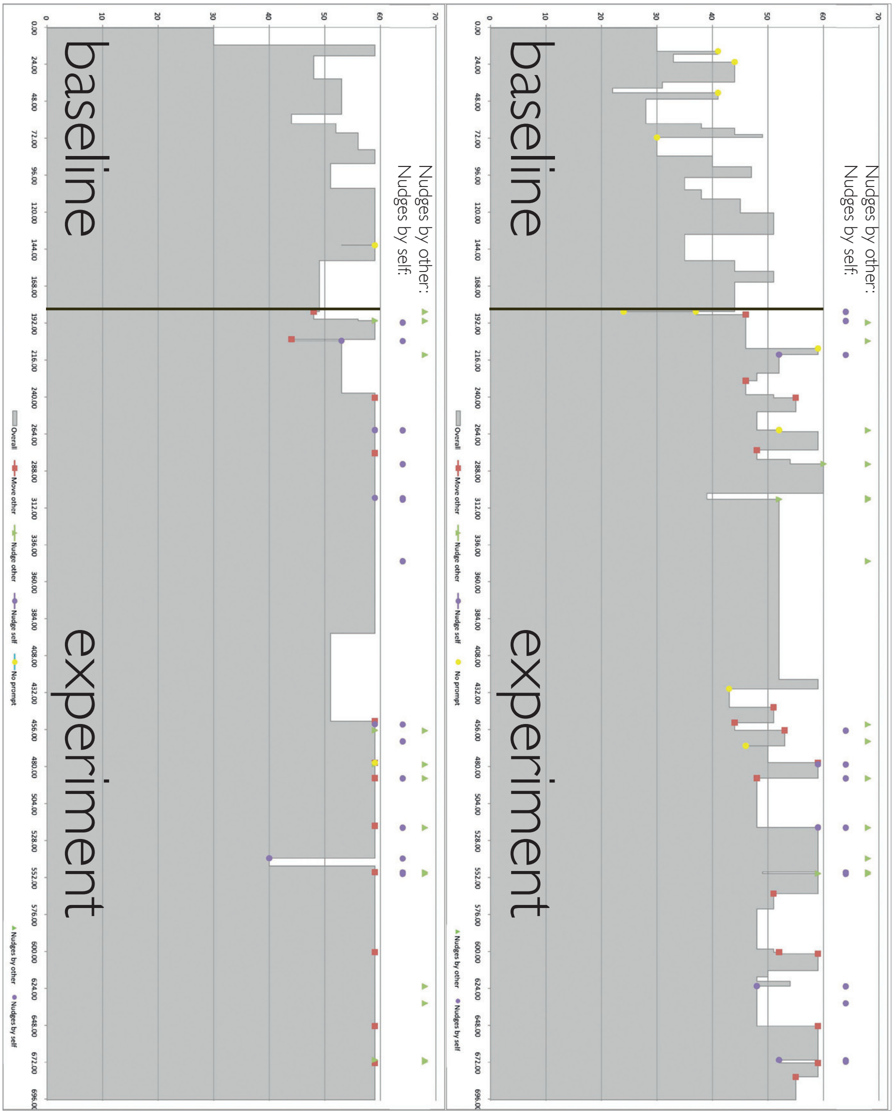


Figure 6.9. Plots of the slider scores over the full duration of the trial, with phatic communication indicated, for Joseph (right) and Jack (left).

Couple 4 – Cindy and Eleanor

Cindy and Eleanor are mother and daughter. They live ±15 km apart. Cindy has a full-time job, and Eleanor is a university grad-student. Eleanor's parents are divorced, and she experiences an equally strong bond with both her mother and father. Both experience their relationship as a strong bond, and they usually share experiences and understanding. They are not continuously aware of each other, but they regularly embark on cultural activities together as means of quality time. Communication is usually through e-mail, and less often through phone or texting Cindy and Eleanor both have a relationship; Cindy lives together with her partner, and Eleanor lives in a student apartment.

Below are some illustrative quotes from the exit interview, at the end of the field trial.

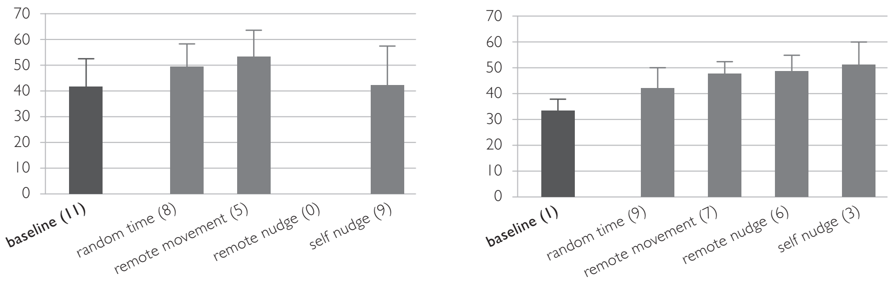
> *"No, I don't think anything changed in our relationship, I feel as connected as always. But I was more aware of them, and I thought about her more often. (Eleanor)*

> *"Only when SnowGlobe lit up I would think of her… I would then imagine what she would be doing… for instance, if it happened at 17:30, I would think of how her day at work was." (Eleanor)*

> *"We would call, sometimes because I saw the globe. I have this feeling she is more open about her feelings now, but I'm not sure that's related to SnowGlobe in any way." (Cindy)*

For both Cindy and Eleanor, the experimental condition fostered more social connectedness than the baseline study; this is evident when observing prompt types, as well as the prompt responses over time (Figure 6.10 and 6.11). Interestingly, contrary to her slider-responses Eleanor mentioned that she was more aware, but that she did not feel more connected. Similar to Joseph (Couple 3), she had the tendency to imagine what was happening in the other location, which stimulated her social awareness. Cindy was somewhat skeptical when expressing what the effect of SnowGlobe was, which matches the data in Figure 6.11. She also reported not to have seen many phatic cues (nudges) coming in –hence the empty bar in Figure 6.10, but she indicated she thought she had set more cues when the data was presented to her at the final interview.

Figure 6.10. Plots displaying the mean closeness scores (0 mm - 60 mm) and SD per prompt type for Cindy (left) and Eleanor (right). Amount of responses collected for each prompt type between brackets.



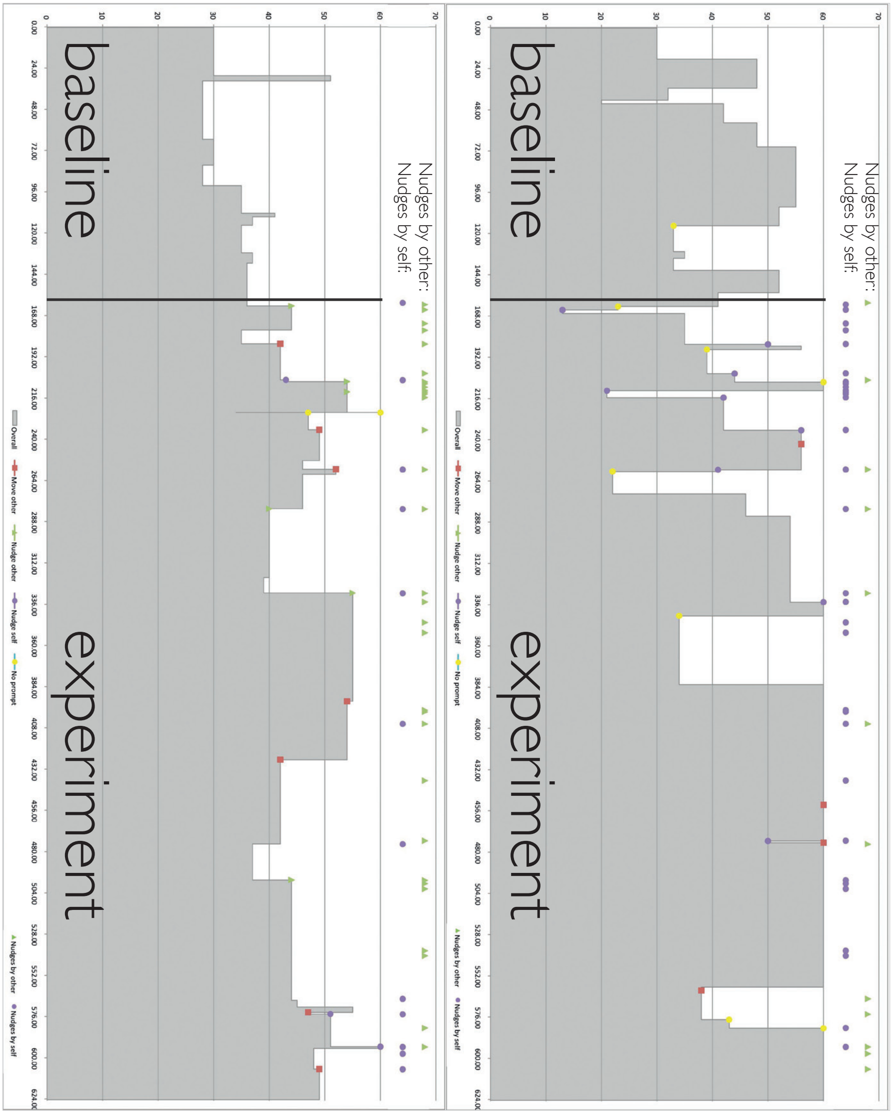


Figure 6.11. Plots of the slider scores over the full duration of the trial, with phatic communication indicated, for Cindy (right) and Eleanor (left).

Summary of results

Despite the small sample size in terms of number of participants, several common trends can be observed across the large amount of data collected. The most salient common results across couples are summarized below.

- All participants have actively used SnowGlobe throughout the duration of the experiment.
- In no case did SnowGlobe negatively influence the experience of social connectedness.
- All participants indicated that they considered both the Closeness Slider and SnowGlobe easy to understand and use.
- No negative experiences during the experiment were reported in the interviews, and all participants reported an increase of the experience of social connectedness in the experimental condition.
- Reported connectedness was found to be higher following sending a phatic cue compared to the responses collected in the control condition.
- Subtle communication mediated by SnowGlobe was found to have either a neutral or a positive effect on connectedness, compared to control.
- In 5 out of 8 cases an increase of connectedness from Baseline to SnowGlobe phase can be observed (Tina, Sandra, Joseph, Jack, and Eleanor).
- People vary greatly in their response behavior, and response interval.
- In at least two cases, participants mentioned that their tendency to attribute meaning to the cues made them think more of the other.
- Participants' recollection of the experiences does not always match their *in-situ* responses on the slider.

Discussion and conclusions

The effects of subtle social cues

The reports collected with the Closeness Slider provided high-detail insights in the developments of the user experience of social connectedness. This helps in understanding the effects of individual user-system interactions. The results show that intentionally *creating* social awareness by sending phatic cues, contributes strongly to connectedness, and subtle social cues in general provide a neutral-to-positive contribution to this experience. The effects on connectedness seem to be small, but due to limited sample size, statistical analysis could not be performed to determine the effect size.

The results regarding the sending of phatic cues, suggests that besides receiving information about relatives, actively contributing to the relatives social awareness about oneself also strongly contributes to feeling close. Previous awareness systems generally focused on the effect of receiving awareness and phatic cues (Gaver, 2002; Khan et al., 2008; Romero et al., 2007). The present research demonstrates the importance of providing an easy to use and intuitively perceived mechanism to support the act of sending a phatic cue as a key designed feature of an awareness system. This can positively influence the sense of social connectedness.

The results regarding the effect of phatic cues on social connectedness is contrary to the results presented in Chapter 2, where phatic cues were studied among couples unknown to each other. Similar to the first SnowGlobe study (Chapter 4), the results in the present study suggest that knowing each other is essential for the effect of phatic cues. The comments of the participants indicating that they had a tendency to attribute meaning to phatic cues based on their knowledge of the routines of their co-participant, support this notion.

The notion that attribution of meaning to any received cues is in line with the findings on the effect of *ambiguity* as described in Chapter 4. In the present study, participants expressed that their tendency to imply meaning for awareness and phatic cues, stimulated their sense of connectedness. From an interaction-design point of view, this is essential, as it means that for such cues to be successful, there should be some room left for interpretation by the user ¬when designing displays. A degree of ambiguity in the display may stimulate effects on experienced connectedness.

An analysis of the longitudinal responses provided valuable insights into the development of the sense of social connectedness over time. Results suggest that the use of the SnowGlobe awareness system had an overall positive influence on the experience of connectedness for most users. In 5 out of 8 cases, a difference in connectedness between the control-phase and experimental-phase was observed, with the latter resulting in higher slider scores, suggesting that SnowGlobe had a positive effect on perceived sense of connectedness. In the remaining 3 cases, the level of connectedness was maintained in relation to the control condition. There are substantial differences between individual responses by participants in terms of the frequency of the responses and the bandwidth used by the participants. This may at least partly be attributed to a difference in the lifestyles of the participants, which are described in Experiment Design section.

When comparing cases in which awareness cues versus phatic cues were received, no particular trends or consistent differences between participants were found in sense of perceived social connectedness. This is likely due to the fact that each participant did not in all cases perceive such cues as particularly positive or negative. This result suggests the need for a large variety of communication functionalities, allowing users to shape their communication behavior reach an optimal perceived degree of social connectedness.

The results collected by the Closeness Slider indicated a neutral to positive effect of SnowGlobe on the experience of social connectedness for all participants. This is supported by the qualitative reports collected in the interviews. Moreover, all of the participants used the system throughout the entire duration of the experimental condition, as indicated by the continuous string of nudges sent. This suggests a short-term novelty effect in using the system only briefly was not prevalent, which is in line with the findings from Chapter 4.

Methodological issues

Participants used the Closeness Slider to report their experiences for the full duration of the experiment. They reported no problems or burden when responding to slider prompts, and the prompts were not considered to be intrusive. Therefore, the goal of the Closeness Slider to minimize the burden imposed on the participant (Chapter 5) can be considered achieved.

A limitation of the approach adopted in the current study was that participants had to be at home to be able to respond to prompts of the Closeness Slider. An example of the impact of the availability factor is, that Couple 2 participants each provided twice as many responses as any other participant, which could be attributed to their homebound lifestyle, as they are retired (Figure 6.6). This suggests that the measurement instrument when used in a fixed location is most useful for user-groups that are frequently at the location of the system under study (such as seniors at home). For other groups, the absence problem could be partly solved by using a mobile device as an ESM tool. However, this would re-introduce problems, such as the burden on the user of always having to remember to take a device with them, and a technology challenge of making the prompts adaptive, at a distance (Intille et al., 2003).

Another limitation of the study setup was that by shear nature, use of the Closeness Slider in itself might have had an effect on social connectedness. This is arguably the case with most self-report scales: participants will think of the other person, once they have to answer a question about that person. The fact that the Closeness Slider physically displays the most recently reported value may possibly contribute to this effect. Note that the within-subject experimental design was intended to control, as far as possible, for the potential effect of the presence of the puppets. SnowGlobe was not present during the baseline measurement period, while the puppets were.

The current method of ESM deployed in the present study could be expanded in the future. For example phone calls and home visits could be logged, which would help to better identify effects on social connectedness caused by external effects. However, asking participants to report these events could impose an additional burden on them and it could be seen as obtrusive and scrutinizing privacy.

Conclusions

This chapter presented a longitudinal study into the effect of subtle social cues of awareness systems, on the experience of social connectedness. The study expands on the first study with the SnowGlobe awareness system (Chapter 4) by measuring the short-term effects on connectedness using the Closeness Slider as the primary measurement instrument.

Results of the study, performed among four participant couples, indicated that the presence of SnowGlobe had an overall positive effect on the experience of social connectedness. This was the case for the full the duration of the trial, for the majority of the participants; no negative effects were observed. In addition, the study demonstrated that creating awareness via sending phatic cues positively influences the perceived sense of social connectedness. Being able to send phatic cues should therefore be considered as key design aspect of social awareness systems in addition to being able to receive awareness and phatic cues.

Participants responded in various ways when awareness and phatic cues were received, not consistently favoring one over the other. Combined with the overall positive effect of SnowGlobe, this suggests that designers of awareness systems should consider implementing communication functionalities at different levels of intention. This would cater for varying user needs and wants, allowing the user to shape their optimal connectedness-experience.

The use of the Closeness Slider in the setup enabled the unobtrusive collection of an average of 115 responses per participant in 4 weeks. It provided a means to gain deeper insight into how the experience of social connectedness is affected by the presence of an awareness system, given several individual communication functionalities, as Experience Sampling-prompts linked to user-system interactions.

7 General findings and discussion

The design activities and experiments described in this thesis aimed at contributing to the primary goal, namely: developing an understanding of how tangible social awareness systems could be designed in order to support social connectedness. In this final chapter, the general findings are summarized, followed by a discussion on methodological issues and applicability of findings. Accordingly, the results of the research are discussed in a broader perspective as they are projected in the context of current social media systems and the current design landscape. Finally, suggestions for future research directions are elaborated upon.

General contributions

Being in touch, and being aware of the people in one's social network contribute to one's sense of social connectedness. In the last decade, communication technology has become more pervasive and ubiquitous, which has made it possible to easily communicate subtle social cues over a distance. The popularity of Facebook for instance, reaching almost a billion users[1], is a manifestation of this trend.

In parallel to developments in social media, people in western societies tend to live increasingly busy lives, creating physical distance from their family and close relations. These developments have created a new challenge for designers: to develop systems that present subtle social cues in the background of our daily lives. In this way, they may enhance our social user experiences by providing us with information and awareness of our relatives. Such subtle cues in this dissertation have shown to help people to pervasively maintain a feeling of being in touch as measured in terms of social connectedness.

1. http://www.pcmag.com/article2/0,2817,2403410,00.asp retrieved 9/9/2012

The present research aimed to provide a better understanding of how social awareness systems could be designed to support the communication of subtle cues between people, supporting social connectedness. The research provided insights on three topics: 1) subtle communication, 2) interaction principles, and 3) design methodology. The first and second topic focus on how social connectedness is affected by subtle social cues, and the user-system interaction, respectively. The third topic focuses on lessons learnt in the design process of social awareness systems.

Subtle communication through awareness systems

The research investigated the effect of two types of subtle communication: 1) awareness cues, which are created non-intentionally, and 2) phatic cues, which are created intentionally. Both types of communication do not imply the exchange of rich content, such as experience, stories of images; rather they are a low-bandwidth connection between two people.

Both awareness and phatic communication through an awareness system contribute to the user experience of social connectedness. Qualitative results from the first field study (Chapter 4) suggest communication through both types of subtle cues contributed to the factors *relationship saliency*, *closeness*, and *being in touch*. Quantitative data from the adaptive experience sampling study in Chapter 6 showed that in most cases, participants continuously experienced increased social connectedness when SnowGlobe was present. These findings are in line with findings from other studies in this domain (in particular: Dey & Guzman, 2006; Khan, et al., 2008; Romero et al., 2007), but additionally contribute to an understanding of individual subtle cues.

The research described in Chapter 6 indicated that users tend to experience a substantial increase in closeness when *sending* phatic cues to a close relative. This finding is important, as it suggests that besides 'being aware of another', being able to *create* social awareness is key to increasing social connectedness. It would appear that users are consciously involved with the relationship when sending phatic cues through an awareness system, thereby thinking more about the relative. Part of the effect may also be explained by the physical interaction required for sending a phatic cue with SnowGlobe (i.e., shaking the device), as this is analogue to 'patting someone on the back'.

There is a difference in the perception of social cues between weak-tie relationships and close relationships. In the case of weak-tie relationships, awareness communication has the strongest effect as was observed in the online study (Chapter 2), whereas for close relationships phatic communication is an important contributor to social connectedness (Chapter 4 and 6). Part of this difference may be caused by the difference in the experimental setup; interaction that led to phatic communication was richer when using SnowGlobe as compared to the online movie-reviewing task.

The difference may also be explained with Hall's theory on personal space (Hall, 1966), stating people prefer different interpersonal interactions depending on the closeness of the relationship. Applied to the present context, phatic interactions may embody a higher level of intimacy compared to awareness interactions, making them more suitable for close relationships. In other words, when people are not relatives or friends, phatic interactions may be considered to be an unwanted form of intimacy for the user.

Another explanation for the differences in experiences observed between close relatives and couples of people is related to attribution. For strangers, who are unaware of each other's socio-contextual background, phatic cues cannot be sufficiently linked to a context, and therefore the cues have no emotional meaning. When a couple is aware of each other's background, on the other hand, the attribution of phatic cues is generally based on a mutual knowledge of each other's the socio-cultural context (Chapter 4 and 6), making it easier for the user to interpret or attribute emotional meaning to the cue. This raises an interesting fundamental question for research into the experience of subtle social communication, namely: How well do two people need to know each other, in order for phatic cues to have a positive effect on social connectedness?

Interaction principles

Physical interaction with social awareness systems can strongly contribute to the experience of social connectedness. Participants in the studies covered in Chapter 3, 4 and 6 indicated that they appreciated elements of touch, as it was analogue to touching their relative. This is in line with the observations by Rittenbruch (2009), who argues tangible awareness systems are more emotionally meaningful than screen-based systems.

An explanation for these observations can be found in *embodiment* theory (Dourish, 2001), which articulates the role of bodily movement in forming experiences. An explanation for these observations may be found in theory on the *affective loop* (Sundström, 2005), which suggests that users may feel more and more engaged with an interactive system, when the system allows them to physically express their emotions, and consequently receive feedback from the system as a response to this. Although SnowGlobe did not respond to the user by itself, the physical action of sending a phatic cue (by shaking) and the possibility of receiving a cue back, may have triggered the emotional engagement with the system in a similar way.

The positive effect of physical interaction is not a novelty effect, as was shown by the results from the longitudinal field studies (Chapter 4 and 6). Participants used the functions of the system during the full duration of the study and reported a continuous increase in connectedness. The research provided empirical evidence for assumptions made in earlier design work (Hindus, et al., 2001; Keller, et al., 2004).

Besides providing insight on the value of a physical interaction modality, the research also provided insights into how the level of detail of the information communicated, may affect social connectedness. Leaving part of the meaning of cues ambiguous can have a positive effect on the user experience: it supports social connectedness and it overcomes privacy issues (Chapter 3 and 4).

The design of social awareness systems

The design of several prototypes helped to understand the complex design space of awareness systems. Although the design process primarily focused on using design as part of research, an iterative design process may help the design of social awareness systems, as described in chapter 3. The design approach built on social well-being theory for the development of interaction and communication functions.

Two key elements of the design approach were 1) leveraging theory on social connectedness, and 2) building prototypes that cover all interaction and tactile qualities. The theory is a structural foundation for system functionalities, and it helps to classify and understand user feedback. The prototypes guide potential users in imagining the effect systems may have on experiences such as closeness and privacy. This is valuable, as users will not only reflect on an envisioned experience, but can also be immersed in the experience by touching and communicating with the system.

Awareness systems versus face-to-face interaction

People tend to strive for an optimum, rather than a maximum, of social contacts and social interactions (Baumeister & Leary, 1995). This could mean that introduction of additional communication tools replaces, rather then complements other ways of communication. In the case of social awareness systems, an ethical concern could be that increased use of the system would mean a decrease in other social contact, such as phone calls or visits.

Also, in the current media landscape, with many social network apps being developed for mobile phones and tablet pc's, the desire for always staying in touch seems ubiquitous. It is well possible that in current society, people are searching for a more effortless way of social interaction. This would mean that people want the gratification of social connectedness, without going through the trouble to achieve it; this thought would render subtle mediated communication as a social well-being drug. In line with this notion, Turkle (2011) suggests that mediated communication technology may induce more and more distance between people, for instance, asynchronous sms-technology is used in contexts were previously face-to-face conversations were started.

Despite these concerns, the two field studies (Chapters 4 and 6) have shown the opposite to happen: a general increase users reported an increased amount of visits and phone calls when having SnowGlobe; a decrease in social contact was not observed. In other words, SnowGlobe triggered the desire to increasingly communicate richer information; which renders SnowGlobe as a teaser, rather than a drug. In line with theory on grounding in communication (Clark & Brennan, 1991), the communication of subtle social cues through awareness systems, may also support the grounding process between two relatives, which is essential for content-related and in-depth communication.

Methodological issues

Research through design

An empirical research-through-design approach (Keyson & Bruns Alonso, 2009) was adopted. Through building several prototypes, this approach enables a quick identification of the relevant issues of a system under study, in cases when no product is readily available. The design iterations in Chapter 3 helped to identify interaction and communication issues underlying the concept of social awareness systems. This step was essential for developing SnowGlobe.

The development of the SnowGlobe prototype early in the research process enabled running several longitudinal pilot and field studies, in which the prototype was evaluated for ±11 months in total. Also, the approach enabled a strong focus on developing field measurement strategies, including the development of the Closeness Slider. This approach is slightly different from other prototypical research-through-design projects (Frens, 2006; Ross, 2008; Wensveen, 2005), in which researchers primarily focused on controlled studies to test a main hypothesis. The approach followed in this dissertation was essential for being able to capture the real-life user experiences of social awareness systems. This helped to improve our understanding of how to design tangible social awareness systems.

Lab, web, and field studies

In this dissertation, the focus was on conducting longitudinal field studies to develop insights on how people use and experience social awareness systems in daily life; a lab and web study were used to support these insights. The focus on studying awareness systems in a field context enabled studying the most authentic user experiences. Previous work has shown that users in controlled lab, or living-lab studies have different behavior, and report different experiences as compared to a real life setting (e.g. Vastenburg, 2007). The fact that participants considered the SnowGlobe awareness system to have become part of their daily life, indicates that the targeted context of use was achieved.

A drawback of field studies involving physical prototypes is that they typically require a high degree of resources, including time and technology readiness (i.e., robustness), and may suffer from a low-*n* (Keller et al., 2004; Rowan & Mynatt, 2005; Visser, Vastenburg, & Keyson, 2010). In addition, the fact that participants are required to have a device in their homes, which some of them may not actually wish to own could be an additional confounding variable. The attitude towards the system may directly influence the responses collected. This may be an explanation for the high variance between subjects in the amount of data collected in the study described in Chapter 6; product use directly affected the amount of prompts.

An advantage of longitudinal field studies is that they may help to counter a novelty-effect; such effects may diminish over time. Research-through-design studies have typically involved studying the user experience with designed artifacts only for a very short time, in most cases less than several hours per trial (e.g. Bruns Alonso, 2010). This makes such studies prone to bias as a result of a novelty effect. In the case of SnowGlobe, user-system behavior turned stable after a maximum of three days, ensuring at minimum more than a week of study in which a novelty bias was less likely. Therefore, although being less controllable, a longitudinal approach provides unique insights into user-adoption over time.

Measuring user experiences in the field

Collecting self-report data from users in a field study can be a challenging task, as users live their normal daily lives, and reporting may easily be considered as a burden. In such studies, a balance has to be found between the level of detail in the experiences that needs to be studied, and the amount of burden that is imposed on the participants. In the research presented in this dissertation, the aim was to quantify short-term effects of human using surveys or scales, and supporting them with the system-logs and participant interviews.

Daily questionnaires that were deployed in the first field study, did not yield new insights, and they were merely perceived as a burden by the participants; a finding similar to e.g. Khan et al., 2008; Romero et al., 2007. Nevertheless, using carefully designed interviews and an accurate user-system interaction log, the studies provided important insights into the use and value of social awareness systems. Also, this approach provided clues about the importance of particular interactions for social connectedness.

To inform the design of awareness systems on a detailed level, it is crucial to understand how participants experience interactions with the system closely after a user-system interaction. The Closeness Slider addressed this problem, by collecting self-report data through an adaptive-ESM approach (Intille, et al., 2003). The design of the slider minimized experience burden by users, as it was easy to understand and users were subtly prompted. When complemented with post-trial interviews, it is also possible to capture underlying user motives and experiences, using a low-burden setup. This is an improvement compared to measurement strategies used in comparable field studies on social awareness systems.

The setup with the Closeness Slider was particularly effective in collecting high sampling rates, with participants that spent substantial parts of the day around their homes. The slider was developed as a physical device that is placed in the home. As a downside, this setup also implied participants needed to be home in order to provide responses. As was found in the second field study (Chapter 6), participants who are away from home a lot may have benefited from a mobile or geo-flexible device.

Another possible future improvement for the setup would be to ask users to report incidental social events at home such as visits of the relative or a phone call. These events may have affected the closeness experience by acting as a confounding variable, challenging the validity of the slider measures at such moments. Although additional information on social events would further increase the accuracy of the Closeness Slider, the researcher should bear in mind that this may impose an additional burden on the participants.

Previous studies into the experience of minimal communication have advocated more qualitative approaches towards exploring the effects of affective interfaces (Isbister & Höök, 2005). Kaye (2006), for instance, argued that a more abstract set of questions (e.g. “What color is your relationship?”) would be better able to understand how a particular affective system is used and perceived by users. Kanis, Perry & Brinkman (2008) have developed a prototype, not just to collect data *in-situ*, but primarily to provoke discussion in an exit-interview. Initially these approaches seem much different from the quantitative approach taken in the present work. However, in all cases, researchers primarily aim to provoke discussion with open questions, aiming to grasp the underlying motives and desires of their actions and behaviors.

The quantitative instruments used in the field studies, and in particular, Closeness Slider (Chapter 5 & 6), aim to reduce a complex experience to a single scale. This was done to reduce the burden on participants, as this was shown to be a problem in previous research (e.g. Khan et al., 2008; Romero et al., 2007). Then, in the exit-interviews the underlying motives and desires of the users were explored. The questions were not as provocative as illustrated above, but the user’s experiences with SnowGlobe for several weeks did provoke them to explain in detail how the device affected their relationship and experiences. This combination of reductive instruments *in-situ*, and a more provocative strategy at the exit-interview, delivered rich insights for future designs of social awareness systems.

Guidelines for social media design

In the present research the focus was on subtle communication. Within that scope two types of cues were distinguished: awareness (intentional) and phatic (non-intentional) social cues. This focus could in theory help the designer of social media systems to focus on principles for supporting social connectedness. In a real-life social media landscape, however, awareness, phatic, and more content-rich ways of communications are often mixed in single services and applications. An instant messenger application (i.e. Skype or MSN), for example, enables awareness of online presence, but it also enables users to exchange images, share experiences through chat, or even engage in video conferencing.

The findings presented in this dissertation may help designers to better understand this complexity of mediated social interactions. The insights were condensed to three guidelines for the design of complex social media systems. The empirical research has identified design principles that are of a fundamental nature; these are described below.

Creating social awareness

The act of creating social awareness for a relative through phatic communication contributes strongly to feelings of closeness. Previous research into awareness systems has primarily focused on the effect of receiving social cues through media (e.g. Kaye, 2006; Rowan & Mynatt, 2005). The present research has identified the value of taking the effort of sending a cue to a relative.

Guideline 1: Design how users can create and send phatic cues

The positive effects of actively sending a social cue to a relative can be explained from research into more traditional ways of communication. The activity of writing a letter to a close relative, for instance, has been found to have a strong effect on feelings of closeness (Barton & Hall, 1999). Obviously, consciously and actively constructing and sending a social cue to a relative makes one think more of the relative, supporting *closeness* and *being in touch* (van Bel, Smolders, IJsselsteijn, & de Kort, 2009).

Communication through digital media is generally less rich and less time consuming, compared to writing a letter, with pen and paper. Although this increases efficiency of communication, for close relationships it may be valuable to engage users more in crafting the communication. The designs detailed in Chapter 3, were used to explore physical ways of communicating phatic cues, and field studies have shown these ways to be engaging and powerful for social connectedness. Designs of existing social media applications on mobile devices, for instance, could benefit from including more physical ways of interacting. This dovetails theory on embodied interaction (Dourish, 2001), affective loops (Sundström, 2005), with subtle communication through social awareness systems.

Expanding the social media landscape

Implementing a large variety of communication possibilities in terms of subtle communication could enable users to personally optimize their sense of connectedness. The results from the field studies suggest a strongly varying preference for communication functions, both between subjects, and within subjects over time.

Guideline 2: Use a spectrum of social interactions, varying in richness, content, and level of intention.

Existing social network services, such as Facebook and Hyves, have implemented functionalities in which users can communicate on different levels of content and interaction richness; users can poke, message, chat and share pictures, but they can also choose to only read other users' posts. Most users rely on a combination of these services for generating their ideal personal communication spectrum (Bumgarner, 2007). The present research contributes to this media landscape in two ways.

First, it introduces tangible social awareness systems as a complementary service. Such systems, through their unobtrusiveness and pervasiveness in the home environment, let users stay in touch and feel connected, without having to actively 'go. Second, a diverse offer of mediated communication tools may possibly best serve users in creating their ideal social interactions at any time. This also includes tools beyond awareness systems, such as social media networks, messengers and games, but also more traditional media such as phone and e-mail.

Ambiguity as a design principle

Ambiguity has previously been coined as a resource for creating intriguing interaction design (Gaver, Beaver, & Benford, 2003). This approach is contrary to traditional HCI, where often usability – efficiency, effectiveness, and ease of learning (Nielsen, 1993) – are considered to be primary goals. However, in a home context designing engaging user experiences seems to be more relevant than efficiency and effectiveness in performing a task. The present research provides empirical evidence that supports the notion that ambiguous interactions can be leveraged to improve the user experience in the context of awareness systems. The user is able to attach meaning to the modus of communication, and use the social awareness system accordingly.

Guideline 3: Consider the use of ambiguity in information, both in sending and receiving, to create engaging social interactions.

In the field studies, the SnowGlobe awareness system provided users with a hunch of what was going on in the relative's home by displaying a movement indication. The vagueness of the feedback, namely LED-brightness and fluttering snowflakes, stimulated users to imagine what was happening at the other side and form their own interpretation and meaning, making them more engaged and making them think more of their relative and their activities. As an additional advantage, vagueness of the display minimized possible privacy problems.

When designing social media applications, designers may want to consider using ambiguity of information and display as a resource for connectedness, rather than considering it to be a design problem. Drawing on human's natural tendency to attribute meaning to stimuli they perceive (Heider, 1958), providing ambiguous information may stimulate people to think about their relationship. The fact that people have a tendency to attribute meaning that is positive for themselves (i.e., *the self-serving bias*) (Miller & Ross, 1975), may be an additional advantage when aiming to shape the optimal user experience.

Future work

The social awareness systems that were designed as part of this research were developed to evaluate particular communication and interaction features, and complement the visions on Calm Computing (Weiser, 1995) and Ambient Intelligence (Aarts & Marzano, 2003). The studies presented in this dissertation were conducted at a time when the landscape of social media technology was drastically changing through the advent of downloadable apps, Internet-enabled mobile devices, and the fast rise of online social network services. The research has focused on understanding fundamental design principles for social awareness systems, which could in the future also be applied as part of existing social applications.

In terms of designing social awareness systems as commercially available products, they should be considered as part of the ecology of interactive devices

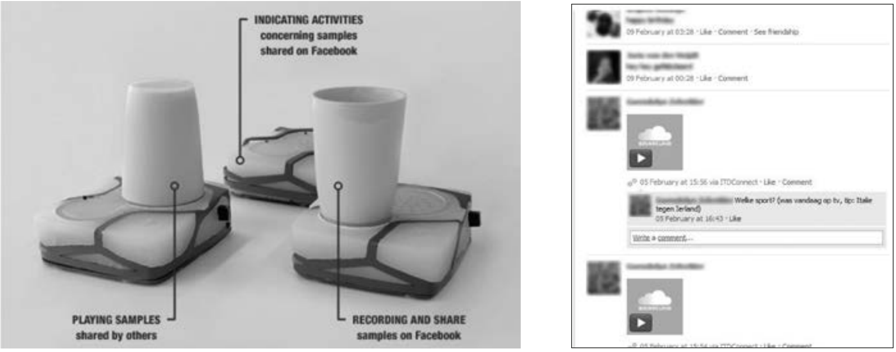


Figure 7.1. The Facebook Listener prototype (left) and Facebook wall posts (right).

and online services already in use. The SnowGlobe system was developed as a stand-alone system, in which both users need a SnowGlobe device to be in touch. However, as the ecology of other social networking services (such as Facebook, Twitter, and Skype) is ever growing, designers need to consider an integration of tangible social awareness systems with existing services.

An example of such a system is the Facebook Listener, which was developed as a spinoff from the SnowGlobe (Figure 7.1; Veen, Visser, & Keyson, 2012). This system is a tangible awareness system that posts to the Facebook wall, and, at the same time, displays information from the users' timeline in a pervasive way. In this way, tangible systems become the pervasive extension of social services already in use. This enables a seamless integration in the existing network of systems already present in the users' homes. Also, it enables users not owning an awareness device to stay in touch, using a mobile phone device.

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Summary

Experiencing social connectedness is important for people's well-being. Hence people have an intrinsic drive to maintain social connections with their friends and relatives. Computing and communication technology have an increasingly important role in facilitating people in their sense of connectedness over a distance. Telephone, E-mail, and chat technologies have been available to people for more than two decades now, supporting them in actively having conversations amongst each other without physically being together

Modern communication and information technology makes it possible to communicate more subtle social cues between people. Such social cues are pieces of information that do not contain rich content, such as experiences, thoughts, or ideas. They rather provide a general awareness of presence or action of another person, similar to social cues observed in every day life. For instance, seeing a car parked in front of someone's house, indicating that person is home, or a neighbor waving to say 'hi' without engaging in further conversation. When created unintentionally, these cues are referred to as *awareness* cues; when created with intention, the cues are called *phatic* cues. Both types of cues have the potential to support people in having a pervasive sense of social connectedness over a distance, in an addition to communication systems they are already using.

Subtle social cues may be created and displayed through a variety of forms and modalities. This research to explored how interactive everyday products may be used to communicate these cues, and how their presence and use support the user's experience of social connectedness. This ties in to visions on future developments of technology, such as The Invisible Computer, Ambient Intelligence and The Internet of Things, which have described technology to become more and more an integrated part in the fabric of people's everyday lives. Systems primarily designed to support people in communicating subtle cues are referred to as *social awareness systems.* Although having been studied before, it has remained unclear whether, and

how the features of such systems actually contribute to social connectedness, making it problematic for designers to design effective social awareness systems.

The primary goal underlying the research of this dissertation was to generate an increased understanding of how social awareness system should leverage *awareness* and *phatic* social cues to support social connectedness for people. The research primarily focused on the use of tangible forms and interactions, as these are considered to be both more meaningful and better integrated in people's home environment.

The first study explored awareness and phatic cues in an online environment. In a controlled web study, participants received different cues from an automated confederate partner, being none in the control condition, a randomly timed reminder, an indication of the other person's keystroke activity (*awareness*), or pokes (*phatic*). Differences with the control condition were marginal. However, contrary to what was expected, phatic cues seemed to be less powerful in fostering social connectedness when compared to awareness cues. This may have been caused by the fact that participants were communicating with someone that was unknown to them, making it problematic to attribute meaning to the cues.

Next, an empirical research through design process led to the development of the SnowGlobe research prototype. Five design cases explored the possibilities of tangible interactive concepts combined with a range of communication strategies. The findings were adopted for the design of the lamp SnowGlobe: a social awareness system that enables two users to exchange both awareness and phatic cues over a distance, for instance, between two living rooms. As one lamp detects motion in one living room, the other lamp will shine brighter. Additionally, when a user shakes one lamp, the other lamp will blink shortly, and snowflakes will flutter around. The system was designed to be used in field studies for studying the effect of awareness and phatic cues over longer periods of time.

The first field study with the SnowGlobe prototype aimed to understand how people use awareness systems in their daily life, and how it affects their experience of social connectedness. Six user couples used SnowGlobe for at least two weeks each. The results from the interviews conducted in this study suggested that, in a case where participants know each other well, both types of subtle social cues may have a positive effect on social connectedness. However, it was problematic to measure how awareness and phatic cues individually contribute to these experiences.

In terms of interaction design, the results confirmed the expected appreciation for a tangible interface. In the domain of social awareness applications, tangible designs may be better able to provide a sense of intimacy, as compared to screen-based systems. The abstract display of SnowGlobe supported users' social connectedness by stimulating them to think of the other person and attribute meaning to the cue. At the same time, it minimized their privacy concerns.

To overcome measurement challenges, a novel field measurement instrument – Closeness Slider – was developed. The instrument adopts an Experience Sampling Method strategy, and it was designed to minimize user burden compared to traditional questionnaires. At the same time enabling researchers to prompt field study participants for their current experience of social connectedness, at any time during the field trial. The instrument was validated in a lab study, where it was compared to traditional social connectedness scales. In addition, a pilot field study explored the practical use of the instrument, and helped to fine-tune the protocol for a second field study with SnowGlobe.

The second field study deployed the slider as the primary measurement instrument for understanding how user-system interactions affected the experience of social connectedness. Four user couples actively used SnowGlobe for three weeks, in which they received daily prompts on the Closeness Slider, partly based on their interaction behavior with SnowGlobe. The Closeness Slider did not collect as much data on particular user-system interaction as expected, but nevertheless, valuable trends were observed. The collected results exposed that sending phatic cues may evoke an increased sense of connectedness. Also, results showed that between participants, responses to various types of cues varied greatly, suggesting that future systems should enable a broad spectrum of subtle communication functionalities.

This research has provided insights into how social awareness systems can affect the experience of social connectedness. In particular, the research has explored the role and effect of subtle social cues, in that context. Although the research primarily focused on tangible interactive systems, the insights may also be applicable for nowadays more and more ubiquitous mobile interactive technologies such as tablets and smartphones. Based on the findings from the studies, the following guidelines for the design of social awareness systems were formed:

1. **Design how users can create and send phatic cues.** Most design and research work has focused on reception and perception of social cues. The studies in this dissertation have shown the crafting of phatic cues to be as least as important for experiencing social connectedness.

2. **Use a spectrum of social interactions, varying in richness, content, and level of intention.** Depending on the situation and type of relationship, people tend to use different strategies in terms of optimizing social connectedness.

3. **Consider the use of ambiguity in information**, both in sending and receiving, to create engaging social interactions. An ambiguous display stimulates people to actively attribute meaning to the cues they receive, thereby inherently thinking more of the other person. In addition, ambiguity helps to maintain privacy for users.

People have an intrinsic desire to maintain their sense of social connectedness, and subtle social cues can support this. The guidelines presented above may help designers to develop systems and applications that are relevant for people's social well-being.

Samenvatting

Het ervaren van sociale verbondenheid, is van belang voor het gevoel van algemeen welzijn. Mensen hebben een intrinsieke drang om hun sociale contacten met vrienden en familie te onderhouden. Informatie en communicatietechnologie spelen een steeds belangrijkere rol in het bijhouden van contacten over langere afstand. Telefoneren, e-mail versturen en chatten op Internet is al meer dan twintig jaar mogelijk. Deze technologieën ondersteunen mensen in het actief meedoen in gesprekken en conversaties, zonder dat ze fysiek bij elkaar in de buurt zijn.

Moderne technologie maakt het mensen mogelijk om ook subtiele sociale signalen te communiceren. Deze signalen gaan niet om het delen van ervaringen, gedachtes, ideeën of andere inhoudelijke zaken. Het zijn eerder signalen die een subtiel bewustzijn teweegbrengen van de aanwezigheid of de bezigheden van een ander persoon. Dergelijke signalen zijn ook te vinden in het dagelijks leven: bijvoorbeeld, het zien van een geparkeerde auto van de buurman, die een indicatie is van dat de buurman thuis is, of een kennis die gedag zwaait op straat, zonder verder in een gesprek over te gaan. Dergelijke signalen kunnen mensen ondersteunen in het krijgen of behouden van een algemeen gevoel van sociale verbondenheid, bovenop bestaande sociale interacties met anderen. Wanneer de signalen zonder bewuste intentie gecreëerd worden, spreekt men van *awareness* signalen; in het geval van een bewuste intentie, spreekt men van *phatische* signalen.

Subtiele sociale signalen kunnen gecreëerd en getoond worden middels een grote variatie aan vormen en modaliteiten. Het huidige onderzoek heeft verkend hoe producten die men dagelijks gebruikt, ingezet kunnen worden om dit soort signalen te communiceren. Daarnaast is er onderzocht hoe deze communicatie bijdraagt aan een gevoel van verbondenheid. Dit onderzoek ligt in lijn met toekomstvisies zoals *The Invisible Computer*, *Ambient Intelligence* en *The Internet of Things*, die beschreven hebben hoe technologie steeds meer geïntegreerd zal zijn in het dagelijks leven. Systemen die ontworpen zijn om in deze context voornamelijk subtiele sociale signalen te communiceren worden *social awareness* systemen (systemen

voor sociaal bewustzijn) genoemd. Hoewel deze systemen eerder al zijn bestudeerd, is het nog niet helder of, en hoe de functies van dergelijke systemen bijdragen aan sociale verbondenheid. Dit maakt het een uitdaging voor ontwerpers om effectieve *social awareness* systemen te ontwerpen.

Het hoofddoel van het onderzoek was om kennis te ontwikkelen over hoe *social awareness* systemen de *awareness* en *phatische* signalen kunnen inzetten om sociale verbondenheid te verhogen. De focus van het onderzoek was op systemen met fysieke vormen en interacties, aangezien deze over het algemeen betekenisvoller worden geacht. Daarnaast zijn ze beter te integreren in de dagelijkse leefomgeving.

De eerste studie verkent *awareness* en *phatische* signalen in een online omgeving. In een webstudie ontvingen deelnemers verschillende signalen van een denkbeeldige partner: geen signaal in de controle conditie, een willekeurig gegeven signaal, een signaal dat de hoeveelheid toetsaanslagen van de partner aangaf (*awareness*), of korte door de partner bewust gegenereerde berichtjes (*phatisch*). Verschillen met de controle conditie waren marginaal. Tegen de verwachting in bleek dat *awareness* signalen een positiever effect hadden op sociale verbondenheid dan de *phatische* signalen. Dit werd waarschijnlijk veroorzaakt doordat deelnemers hun partner niet kenden, waardoor de signalen voor hen geen betekenis hadden.

Vervolgens is het SnowGlobe onderzoeksprototype ontwikkeld. Vijf design cases hebben fysieke interactieconcepten gecombineerd met een reeks aan communicatie strategieën. De bevindingen uit die cases zijn gebruikt in het ontwerp van de lamp SnowGlobe: een systeem dat twee gebruikers in staat stelt om zowel *awareness* als *phatische* signalen te communiceren over een afstand, bijvoorbeeld tussen twee woonkamers. Als de ene lamp beweging detecteert, zal de andere lamp feller gaan branden. Daarnaast, als een lamp geschud wordt, zal de andere lamp knipperen en er zullen sneeuwvlokjes ronddwarrelen. Het systeem is ontworpen om in veldstudies gedurende langere tijd het effect van subtiele sociale signalen te kunnen onderzoeken.

De eerste veldstudie met de SnowGlobe prototypes had als doel inzicht te krijgen in hoe mensen *social awareness* systemen gebruiken in hun dagelijks leven, en om te begrijpen hoe dat hun gevoel van sociale verbondenheid beïnvloedt. Zes koppels hebben ieder gedurende minimaal twee weken SnowGlobe gebruikt. De resultaten uit interviews gaven aan dat, in een geval waar partners elkaar goed kennen, beide typen subtiele sociale signalen een positief effect kunnen hebben op sociale verbondenheid. Het was echter moeilijk om de effecten van *awareness* en *phatische* signalen afzonderlijk te bestuderen.

Wat betreft het ontwerp van SnowGlobe, bevestigden de resultaten de verwachtte waardering voor een fysieke interface. Het is aannemelijk dat dergelijke interfaces in dit domein beter in staat zijn om een gevoel van intimiteit te geven dan scherminterfaces. Het abstracte display van SnowGlobe ondersteunde sociale verbondenheid door gebruikers te prikkelen betekenis te geven aan signalen, en daardoor aan de ander te denken. Daarnaast, bleef de privacy van de gebruiker gewaarborgd.

Om in veldstudies gedetailleerdere metingen te kunnen doen van sociale verbondenheid, is de Closeness Slider ontwikkeld. Door met een fysieke schuifknop twee poppetjes naar elkaar toe of van elkaar af te schuiven, kunnen participanten eenvoudig aangeven hoe verbonden ze zich op een specifiek moment voelen. Het instrument is ontworpen om de belasting te verlagen die conventionele vragenlijsten anders aan participanten zou opleggen. Daarnaast stelt het onderzoekers in staat om participanten op elk moment tijdens een veldstudie te vragen naar hun gevoel van sociale verbondenheid. Indien wenselijk kan deze vraag gekoppeld worden aan de interactie met een systeem zoals SnowGlobe. Het instrument is gevalideerd in een labstudie, en het bijbehorende protocol is verder verfijnd in een proef veldstudie.

In de tweede veldstudie is de Closeness Slider gebruikt als hoofd meetinstrument om inzicht te krijgen in hoe de gebruiker-systeem interactie bijdraagt aan sociale verbondenheid. Vier koppels hebben gedurende drie weken SnowGlobe gebruikt, ze werden dagelijks automatisch door het instrument gevraagd om hun respons. Ondanks dat er minder data is verzameld dan dat verwacht werd, zijn er waardevolle inzichten naar boven gekomen. De resultaten gaven aan dat juist het verzenden van *phatische* signalen belangrijk is voor sociale verbondenheid. Ook bleek het dat de respons tussen participanten sterk varieerde. Dit suggereert dat toekomstige systemen een breed spectrum aan communicatiefuncties mogelijk moet maken.

Door de hierboven beschreven studies is inzicht verkregen in hoe *social awareness* systemen bij kunnen dragen aan een gevoel van verbondenheid. De nadruk van het onderzoek lag hierbij op het effect van subtiele sociale signalen. Hoewel het onderzoek voornamelijk gericht was op tastbare interactieve producten, zijn de verkregen inzichten mogelijk ook van toepassing voor hedendaags alom aanwezige mobiele technologieën, zoals tablet PC's en smartphones. Aan de hand van de bevindingen uit het onderzoek, zijn drie richtlijnen voor het ontwerp van *social awareness* systemen geformuleerd:

1. **Ontwerp hoe gebruikers *phatische* signalen kunnen creëren en verzenden.** Het genereren van dergelijke signalen is minstens zo belangrijk als het ontvangen ervan.

2. **Gebruik een breed spectrum aan sociale interactiemogelijkheden,** variërend in inhoud, intentie en type interactie. Afhankelijk van de situatie en het type relatie gebruiken mensen verschillende strategieën om hun gevoel van sociale verbondenheid te optimaliseren.

3. **Overweeg het gebruik van ambigue informatie.** Dit betreft zowel het verzenden als het ontvangen van sociale signalen. Een ambigu display stimuleert mensen om actief betekenis te geven aan wat ze ervaren waardoor ze meer aan de ander denken. Daarnaast helpt het om privacy problemen te voorkomen.

Mensen hebben een intrinsieke drang om sociaal verbonden te zijn, en subtiele sociale signalen kunnen hier aan bijdragen. De bovenstaande richtlijnen kunnen ontwerpers helpen om systemen en applicaties te ontwerpen, die relevant zijn voor het sociaal welzijn van mensen.

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About the author

Thomas Visser was born on November 3rd, 1983 in Naarden. After completing his secondary education at Alberdingk Thijm College in Hilversum, he enrolled in the bachelor and, subsequently, the master program in Industrial Design at Eindhoven University of Technology. During this time, he spent six months at the Design Academy Eindhoven and he collaborated on a research project at the EMPA institute (Switzerland). For his graduation, Thomas was involved in a design and research project for TNO Defence Safety and Security, which he completed in 2007, when he received his Masters of Science degree.

After graduation, Thomas worked as an interaction designer at TNO Defence, Safety and Security. Also, he won the Samsung Innovation Quest in 2008, in London, UK.

Thomas started his PhD research at the department of Industrial Design Engineering of Delft University of Technology in 2008. His research focused on the design of subtle communication systems to enhance the experience of connectedness. As part of this research, he spent several months at the CHIMe lab at Stanford University (USA).

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Author publications

First Author

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