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## Connecting the family with awareness systems

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**Abstract** Awareness systems have attracted significant research interest for their potential to support interpersonal relationships. Investigations of awareness systems for the domestic environment have suggested that such systems can help individuals stay in touch with dear friends or family and provide affective benefits to their users. Our research provides empirical evidence to refine and substantiate such suggestions. We report our experience with designing and evaluating the ASTRA awareness system, for connecting households and mobile family members. We introduce the concept of connectedness and its measurement through the Affective Benefits and Costs of communication questionnaire (ABC-Q). We inform results that testify the benefits of sharing experiences at the moment they happen without interrupting potential receivers. Finally, we document the role that lightweight, picture-based communication can play in the range of communication media available.

### 1 Introduction

Awareness systems are a class of Computer Mediated Communication (CMC) systems that support individuals to maintain a peripheral awareness of each other's

activity, with low effort and over medium to longer periods of time. Pioneering awareness systems focused on the workplace, as for example Media Spaces [1] or Portholes [2], which provided video-based awareness of colleagues in an office environment.

An early conception of an awareness system for the home is the Digital Family Portrait, developed at Georgia Tech [3] that examined abstract visualizations of data regarding the well-being of an elderly relative, in a form appropriate for a home environment. The Casablanca project [4] proposed several industrial design prototypes of simple and lightweight means of communication. Examples are their "Intentional Presence Lamp" which lights up when remotely located individuals choose to indicate their presence at home, or the "Scan Board" which enables two households to share a writing surface. There is very little experience to this point with the deployment and use of such systems specifically for the home, so the way they are experienced by users is largely speculative. A notable exception is the recently completed InterLiving project [5], where prototypes were field-tested for periods of 6 months and rich ethnographic data was collected to document their usage. Two more recent works, both based on the concept of Digital Portrait, present field studies that assess home-monitoring applications. The CareNet Display [6] looks at the needs of the potential users on how they want to see the information collected from the elder. Their field study focuses on how to display the information gathered and not on how to collect the necessary information (in the study they simulated the use of sensors with explicit phone calls to the elder and to the closest caregivers). The Digital Family Portrait Field Trial [7] presents a long-term field trial between one elder and her adult child that lives apart. This work addresses many of the open issues described by CareNet, which refer to the use of sensors to collect data and the impact of such technology by introducing sensors in the elder's home.

Apart from related research still being sparse, little has been accomplished in the way of explaining the

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concept of awareness itself, to account for the mechanisms by which people try to stay in touch and to specify the nature of the affective benefits they can experience through the use of awareness systems.

Researchers approach the concept of awareness from several angles. Works like the AROMA project [8] and the Digital Family Portrait [3] mentioned above focus on achieving awareness with minimal cognitive effort, through pre-attentive processes of the user. The design of non-disruptive and perhaps ambient displays is a critical component of these works. As such, the philosophy of calm computing as formulated by Weiser and Brown [9] can be recognized. Another critical issue in such efforts is how to achieve a balance between what information people would like to know about others or, conversely, to make known to others. There is a trade-off between trying to address the need to communicate and the need for privacy, which gets reflected in the level of detail/abstraction of information displayed.

Perhaps more important for informing the design of future awareness systems is to appreciate the benefits that users experience through interacting with awareness systems and the role they can play in the gamut of social interactions of an individual. This broader perspective is pursued by [10] who define *affective awareness* as “the general sense of being in touch with someone’s friends and family”. However, the exact nature of this feeling, how to achieve it, and how to assess it remain unexplored to date.

Substantial theoretical work has gone into defining and measuring the experience of *social presence* [11]; this sensation pertains to the ability of a communication medium to emulate face-to-face presence through its capacity to carry interpersonal communication cues. Social presence as a concept originates from the study of synchronous communication where it provides a human centric benchmark for the comparison of communication media. Using measurement instruments such as the social presence questionnaire developed by [11], or its extension described in [12], different media or systems can be directly evaluated with respect to how close they emulate the experience of face-to-face interaction between humans (Table 1).

Typical for research in social presence is that communication takes place in the individual’s centre of attention. A somewhat different approach is reported in [13], where social presence was achieved through providing peripheral awareness of a remote individual or a group. In that experiment, a peripheral display of a remote friend watching the same television program resulted in the test-participants feeling increased social presence and was related to higher levels of group attraction, potentially strengthening existing social relationships. A question that arises is whether and how awareness relates to social presence and how awareness can support the need for social affiliation, the need of an individual to belong to a group.

The present paper discusses an investigation of these concepts in the context of intra-family communication. To scope the research effort we focused on three-gen-

eration families: grandparents living in a different household than their children and grandchildren. Increasing factors such as emigration and mobility of professionals make these groups primary potential beneficiaries of awareness systems (cf. [3, 4, 14]).

In the following sections, we describe work that explores the affective need for peripheral awareness of close family members and how that need is currently addressed by existing communication media (Sect. 2). This research has led us to the definition of the concept of connectedness and has required us the development of a tool to perform quantitative analysis (Sect. 3). It also informed the design and implementation of the ASTRA awareness system (Sect. 4). Next, we present both a laboratory (Sect. 5) and a field (Sect. 6) experiment for a usability evaluation and an assessment of affective costs and benefits of ASTRA, respectively. Finally, a summary of the most relevant results is presented (Sect. 7) and a discussion with ramifications of our experiences (Sect. 8).

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## 2 The benefits and costs of communication

### 2.1 A qualitative inquiry into informal social communications

A necessary first step in investigating informal social communication needs and ways to support people in this respect was to explore people’s *current* communication patterns within their family and their use of communication technologies to communicate between households. We were interested in documenting both the positive and negative experiences associated with those technologies, as well as identifying potential unfulfilled social communication needs not addressed by existing communication technologies. Additionally, we wanted to obtain a clearer picture of how some of our preliminary conceptions of awareness systems would be perceived by the participants in serving their social communication needs. To this end, we set up a two-tier qualitative inquiry consisting of an interview study and a diary study.

Semi-structured interviews were conducted with 17 participants: 3 family clusters and 4 additional individuals. By family clusters we mean individuals related by family ties, who live in more than one household. On average, an interview lasted about 1 h. Interviews had three parts:

- Communication within the family: In this part participants were asked to describe their family, their current communication patterns, and the importance they attributed to communication with the family. Finally, they were asked to describe one recent contact with a family member which they experienced as very pleasant or special, and one contact they experienced as unpleasant or unsuccessful.
- Tech-tour: In this part participants showed which means they use to communicate with their family. For

each medium, they were asked to describe how often they use it, if they feel connected to their communication partner when using it, and how long this feeling lasts.

- **Guided speculation:** Participants were asked to react on the concept of an awareness system and questions such as what kind of information they would like to send and for what purposes they would use an asynchronous system.

Each of the 13 participants who made up the 3 family clusters studied, kept a diary of their informal social use of communication media for 1 week. We created diaries using simple, informal language and inspiring drawings to set an open and inviting channel of communication with our participants. Questions were open-ended to elicit personal, qualitative information. The participants of the diary study were asked to record each contact with their family members and to answer questions about the time, duration, communication means, location, the other person, initiative, reason, their feelings, whether they felt 'in touch', the after-effects of the communication and the presumed feelings of the other person.

For the two children, we created a separate and simpler version of the diary. They were asked to write down the time, to describe what happened, who the other person was and how they felt. Also, they were asked to make a drawing of each contact. Figure 1 shows an example of a completed page of the diary given to children.

## 2.2 Analysis of the qualitative data

A total of 103 contacts were recorded in the diaries. Of these, 22 were excluded from further analysis, because they were between members of the same household and therefore outside the focus of this study. There were only five contacts of which we could not find a matching entry for the two communicating individuals, which indicates that the diaries offer a relatively complete overview of the contacts that took place during the week. A debriefing interview was conducted after participants had completed their diaries. We noted that diary-keeping was more enthusiastic in the beginning of the week, becoming somewhat laconic at the end of the week.

Affinity diagrams [15] were used to analyse the results of interviews and diaries. Affinity diagrams are a technique for analysing qualitative data that helps identify emerging concepts and patterns. Three individuals clustered diary entries along several dimensions. Corresponding codes were entered into a spreadsheet that helped create several quantitative summaries highlighting interesting patterns in the data. The results of the interviews were analysed by comparing the answers of all participants for each question or topic, in order to uncover differences and similarities.



**Fig. 1** In this diary page the child illustrates the content of an e-mail she sent to her grandmother telling that a friend of her went to the hairdresser

## 2.3 Results

### 2.3.1 Value of the communication

First, we found that effort invested by the sender of a message is valued by the receiver, but only when it is *meaningful* with respect to the communication message. For example, the effort taken to start up a PC, dial-up a service provider and send an e-mail message (i.e., process effort) is not valued compared to the effort of choosing a postcard to fit the personal taste of the receiver. For example, one participant commented (all quotes translated from Dutch):

“I received a Christmas card from my sister, which was very nice. There was a bird on it. I like birds, so I know that she especially selected it for me.”

This implies that an awareness system should support this *personally targeted effort* to be committed by the sender and perceived as such by the receiver.

Second, the *timing* of the communication is crucial. Participants indicated that they would like to share events of their everyday life with their relatives, right at the moment when they happen. At the same time, timing for receiving a message should be negotiated with the receivers so as not to disrupt the activity they are engaged in. This suggests advantages for asynchronous awareness systems, as indeed argued in [14].

Third, nearly all participants said that abstract information (e.g., symbolic icons or text labels) regarding the availability, status or activities of their family members would not be sufficient for them to create a feeling of connectedness. This confirms two earlier studies we have conducted [13, 14] pointing against the use of abstract displays for awareness systems. Rather, communication with *concrete images* was required by participants, perhaps as an aid to phone conversations.

Four, the *surprise* factor is valued, while routine communications are not; this observation pertains both to the timing as well as to the content of communication.

Finally, communications for social purposes create *obligations* but also are valued less when they seem to be obligatory. There is reticence by participants to adopt media that will create new expectations on the part of the receiver and subsequent obligations on the part of the sender. The following quote from a participant illustrates both the routine effect mentioned earlier, as well as the negative perception of obligatory communication:

“My mum almost always calls me in the weekend. Most of the times it’s nice, but sometimes I can tell that she only calls because she feels obliged to and then the conversation is a bit forced.”

The social costs of violating expectations are illustrated in the following quote:

“We forgot to call our daughter in return to her voice-mail message on New Year’s Eve. She finally called herself and I could tell she was a bit disappointed.”

Participants saw value in enhancing the existing media rather than replacing them: talking about an item/message of an asynchronous service during a phone conversation, or using it as a reminder for calling someone.

### 2.3.2 Purpose of the communication

As also shown in [14], it seems that especially older men need the pretext of some practical matter, before they initiate a communication. Most emotional/social contacts were carried out by women, and these were perceived as most positive when one of the communicators initiated the communication to “tell” something rather than to ask for advice or simply to chat. The feelings associated with general social communications were, as expected, more positive than those associated with practical purposes (see Fig. 2). Occasional communication (i.e., related to a special occasion, such as a birthday, or New Year) was largely valued as ‘neutral’. One reading of our results is that we should try to increase the opportunities for social and emotional communications where the initiator has something to tell. Figure 3 shows an important use of asynchronous media to support social communication (Fig. 3a), but at the same time demonstrates a failure in achieving higher positive feelings (Fig. 3b). This presents us a design opportunity to search for more adequate usage of asynchronous systems to support social communication.

### 2.3.3 Social presence and connectedness

Participants reported experiences of social presence (a sense of ‘being together’ enabled through mediated communication), particularly when discussing their usage of the telephone. In addition, however, they also

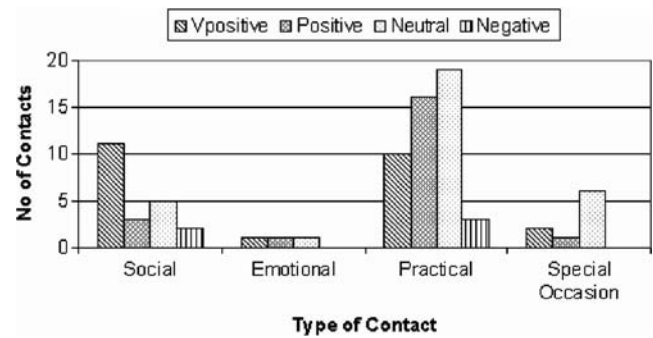


Fig. 2 This chart illustrates the feelings associated with the different type of contacts defined in this study. Very positive feelings were more related to social type of contacts than practical contacts

described feelings, which are of a different nature and go beyond the scope of the social presence concept. An example is the high appreciation of postcards, which are valued because they are perceived as very personal and can be kept as a permanent reminder of the person who sent it. A similar persistency can be observed in participants’ description of after-effects of contacts:

“If the other person makes me feel better, I keep that feeling with me for a long time.”

Such after-effects were generally described as feelings of thinking about the other person, feeling in touch, and being involved in each other’s life. These feelings appear not to be directly associated with contacts, but lingering

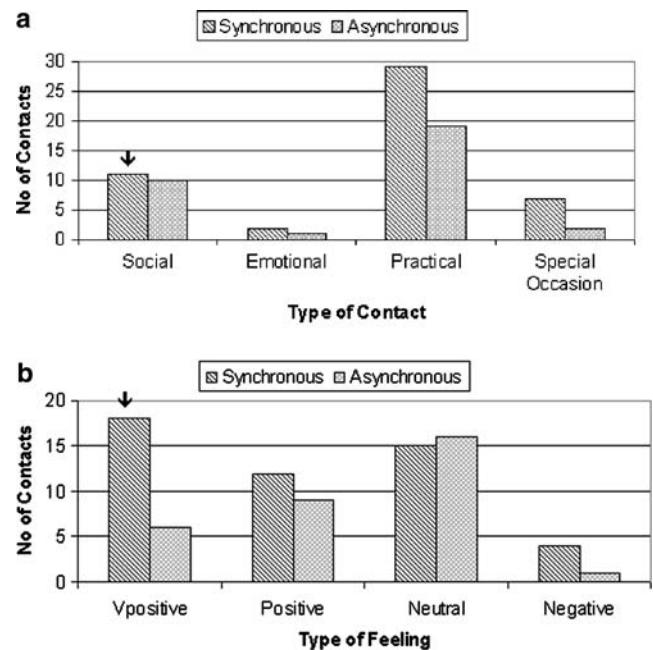


Fig. 3 a The chart the current use of synchronous and asynchronous media, where both types of media are being used approximately equally often for social contacts. b The chart on the right indicates that for existing media, synchronous media are associated more clearly with positive feelings

in the background more or less persistently, as is illustrated in this quote:

“It depends on what I do afterwards, if I am distracted it goes away. But then it often comes back when I am in bed, or the next day.”

To us, these descriptions pointed to a clear need for *connectedness*, which we defined as ‘positive emotional appraisal, characterized by a feeling of staying in touch within ongoing social relationships’ [16]. Throughout and beyond the ASTRA project, the connectedness concept has proved a useful complement to the range of concepts used to characterize the feelings associated with mediated communication.

## 2.4 Conclusions

The inquiry into user needs from communication has led to the following conclusions:

- Some of the most valued aspects of informal social communications are the personal effort put by the other party, the mere fact that one is thought about, the social content of the message, the well-selected content, e.g., an image or a message that is concrete rather than an abstract visualization.
- Only a small proportion of communications have a social content. It seems that for many individuals there may be a threshold before engaging in communications of a purely social nature despite the fact that these are highly valued. Utility-oriented topics of conversation are sometimes needed (and appreciated) as an excuse for engaging in emotionally gratifying communication.
- The feelings that our participants reported as arising from communication can only partly be classified as social presence. The concept of connectedness was introduced to encapsulate the more stable, longer-term feeling of social inclusion and affection within intimate social networks, pointing towards a clear design space for lightweight social and intimate awareness systems in the home context.

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## 3 Measurement of affective benefits and costs of communication

In order to provide an operationalization and a measurement instrument to quantify the affective qualities of telecommunication systems, we developed the Affective Benefits and Costs of Communication questionnaire (ABC-Q). This was used during the evaluation of the ASTRA system that is introduced in the following section.

From the qualitative data obtained it was clear that mediated communication brings about both benefits and costs. Some of the benefits relate to the concept of

connectedness described earlier, like feeling in touch with someone, being aware of what they are doing or of their general well-being. On the other hand, communication was also perceived to bring about costs, including loss of privacy, unfulfilled expectations, or the creation of new obligations.

The ABC-Q was specifically designed to assess the affective benefits and costs of communication, as they arise from using an awareness system or any other communication medium, in the context of social and emotional communications. The questionnaire development was informed by the user study reported earlier, plus some qualitative research into what it means for geographically separated family members to stay in touch. A first version of the questionnaire was created consisting of 58 items accompanied by 7-point Likert scales. After a preliminary study for item selection that involved 20 participants, this list was narrowed down to 36 items, with a satisfactory Cronbach’s alpha of  $\alpha = 0.86$  for the complete questionnaire. The development and the full content of the questionnaire have been discussed in a separate publication [17].<sup>1</sup>

The final ABC questionnaire includes the following scales:

- Obligations: social obligations felt or created as a result of the communication activity.
- Expectations: raised expectations or unmet expectations for communication.
- Threats to privacy: the extent to which communication threatens one’s privacy.
- Thinking about: thinking about each other and knowing one is thought about.
- Need to be informed: knowledge of other people’s activities.
- Staying in touch: the feeling of being connected.
- Sharing experiences: how much one feels other people are involved in his/her life, sharing experiences.
- Recognition: the extent to which each other’s feelings are understood.
- Group attraction: the feeling of being part of a group.

The items assessing group attraction were not developed in this study since a suitable instrument was already available: the Group Attitude Scale by [18]. The four items most appropriate to our situation were taken from this instrument and were incorporated in the ABC-Q.

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## 4 The ASTRA awareness system concept

### 4.1 Conceptual design

The ASTRA system was designed and developed with the aim to yield the benefits of connectedness while incurring small affective costs. Taking into account the

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<sup>1</sup>More information can be obtained from: <http://www.ijselsteijn.nl/ABC-Q.html>.

outcomes of the qualitative investigation described above, the ASTRA system was conceived as a supplement to existing communication media. During the day users could opportunistically capture thoughts or moments they wish to share. These entered a ‘To-Tell’ list (named so in direct analogy to the common To-Do lists). This list of topics could be shared within the family or between family members for discussion over the phone, SMS, or through e-mail. This To-Tell list may be accessed or amended on the move or at home. At home this list will be displayed as a peripheral display that stays discretely in the background when unattended. For example, it could occupy the television screen or some other display in the home, like an electronic picture frame, the television, or the PC when that is idle. While these devices are sufficient during background operation, a device that can be moved easily within a home is needed for actual operation. The system should be used as an auxiliary resource during other forms of interaction that may take place at different rooms. Thus, mobility within the home is also a crucial form factor for the home device. The To-Tell list should be easy to access and browse during other communication activities. For example it might be interesting to access it while talking on the phone: items should provide a conversational prop or even a trigger for discussions or other forms of communication with complementary media. Sharing daily-life moments gives also an overview of what the other person is doing. This overview can build up in the background a peripheral awareness of others’ activities presented as a lightweight acknowledge mode of communication.

Figure 4 illustrates how this concept was eventually realized with the ASTRA prototype. A user who is away from home uses a mobile device that supports picture taking and freehand drawing and writing, to create and send a message to the home of a friend or family member. At home, this message can be seen using the tablet device shown at the middle of Fig. 4. When the user at home does not interact with the device this shows an overview of such messages, which looks like a spiral. The person at home uses the tablet device with its touch-screen interface to browse similar messages or check the availability of others that are also connected to the system.

The concept described above is designed to provide friends or family members with an opportunity to become more involved in each other’s lives by staying aware of each other’s daily activities and experiences. It allows the sender to share moments of his or her life as they happen, thereby enhancing the opportunities to share context and time-specific information with social significance. The asynchronous nature of the system allows individuals to choose the moments for sharing and receiving, therefore not disrupting them in their daily flow. At the same time, it is expected to enhance existing ways of synchronous communication by triggering and providing content for contacts. This is supported by the availability information, e.g., whether



Fig. 4 Sharing experiences with the ASTRA system: taking a picture while on the move, adding a handwritten note or sketch, receiving in a homebound device, viewing in a relaxed place

someone is reachable by telephone, instant messaging, SMS or e-mail.

For the prototyping phase of the project a mobile phone was used (Sony-Ericsson P800) that had sufficient built-in functionality to support the mobile user in the scenario above. This practical choice meant that a general-purpose mail application was used instead of having an ASTRA mobile application running on the phone. This functionality is currently under implementation and will allow the phone to act as a mobile awareness display.

ASTRA is designed to encourage people to capture their own pictures and adding small notes to it, as a personal value to the communication activity, without affecting its lightness.

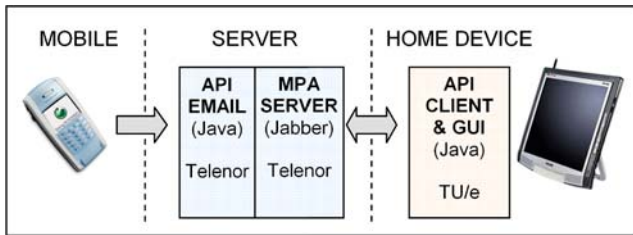
Table 1 summarizes the main characteristics of the ASTRA system along with the requirements that it tries to respond to.

#### 4.2 Detailed implementation

Users operate the ASTRA system through a desXcape display (the latest wireless LCD monitors by Philips). This wireless monitor affords touch-screen interaction and can easily be carried around in order to maximize the freedom of the user. The software for the homebound application runs on a PC. It is a Java client,

Table 1 User requirements and design decisions

Requirement for affective awareness	Feature of ASTRA system
Personal effort (meaningful communication)	Users can easily capture and send pictures, along with handwritten notes.
Timing (the right moment)	Communication is asynchronous
Concrete information (visual cues)	Pictures capture daily-life moments



**Fig. 5** ASTRA architecture. The *server side* provides the interface to receive the e-mails sent from the mobile devices and transform them in a proper MPA service. The *client side* listens to the MPA services and shows that information in a graphic interface at the home device

implemented in Java SDK 2, version 1.4.1. A mobile Java client is currently under implementation for the next version of the system. For the field tests, we used the existing functionality of the Sony Ericsson P800 third generation mobile phone, to create and send e-mail messages to the Mobile Presence Platform (MPP). The clients (home and mobile) were running in the Netherlands while the MPP server was physically in Norway. A local telecom company provided a GPRS (General Packet Radio Service) connection to connect the mobile phone with the server by e-mail. Figure 5 illustrates the client-server architecture developed by Telenor (server) and TU/e (API client).

The design and implementation focused on the home application while we used existing applications and services for sending pictures with handwritten text messages from the mobile phone. The design of the home application proceeded in a traditional iterative manner with testing of early prototypes before the final design was produced. As the device must fit a home context, particular care was taken to design a consumer electronics interface suitable for the home, rather than one for a personal computer. For example, elements typical of computing environments are avoided (such as logging-in, navigation between many screens, overlapping windows) and a pleasurable smooth interaction was created following the principles of maximizing display “inertia” through smooth animations and avoiding segmentation of the interaction across multiple screens.

**Fig. 6 a** The spiral view illustrates the personal view of the first local user. Reachability information is shown as a pop-up menu. **b** Full view shows the full screen of a selected picture from the spiral. Options to see additional text, to come back to the spiral view and to reply to that picture can be accessed from this view



Figure 6 illustrates the eventual design of the graphical interface for the home device, which can present three views:

- The spiral view serves as an overview display for the home user. The information displayed consists of pictures or drawings and text notes made on the mobile device.
- The full screen view provides a zoomed view of a picture/drawing along with the options to display or to reply to the attached text note if one exists.
- The slide show view is a passive/background display that shows a sequence of pictures/drawings that are currently contained in the spiral.

A spiral was chosen as a visualization technique (Fig. 6a), to display a time-line because of its traditional use as a symbol of time passage, going back to ancient times. It was inspired by designs such as the SpiraClock [19] and children’s digital library [20].

The spiral is divided into three areas. The main area of the spiral holds six pictures, whose size and position portray the recency of the items shown. The centre of the spiral gives access to earlier items while the outer end gives access to more recent ones.

The pictures in the upper right area of the screen represent the members of the local household. In this area the owners of the device can choose to view items, which were sent to them individually by touching their own picture. We have deliberately avoided security features like user identification; contrary to the work environment we can expect members of the same household to negotiate privacy by social rules and rituals as they do for their other activities, e.g., not opening a door without knocking and not opening another person’s drawers. Pictures placed in the lower right corner of the screen represent the members of the remote household. Users can reduce the contents of the spiral to items exchanged between themselves and a specific remote person by touching that person’s picture.

## 5 Laboratory evaluation

A first evaluation study was conducted in the HomeLab. This is a purpose-built laboratory within a research

campus. It is similar to a house apart from being rich in technological infrastructure and state-of-the art observation equipment. The aim of this test was to act as a usability evaluation and a technical check to assure an easy to use and robust system for the field study.

### 5.1 Participants

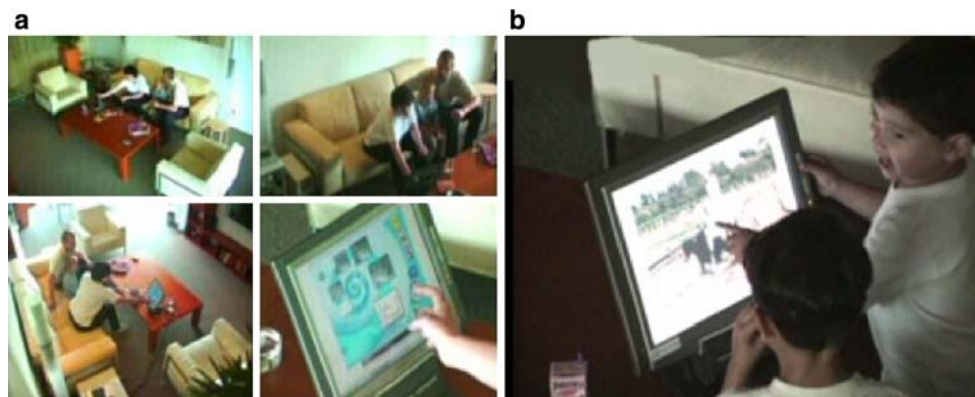
Four families (parents with children) and one group of close friends were recruited through e-mail adverts. In total 19 people (11 males and 8 females) took part; 11 were adults and 8 children.

### 5.2 Set-up and procedure

From each group one person stayed in the HomeLab, while the others visited a museum nearby. We chose the “Historisch Openluchtmuseum Eindhoven”, a historical open-air museum that allows visitors to walk around medieval villages and prehistoric settlements to experience how Dutch ancestors used to live and work. This appeared to be a good set-up to encourage the mobile participants to share moments with the participant in the lab. Also, its proximity to the Homelab made the logistics of the experiment easier. The mobile participants were given the Sony Ericsson P800 mobile phone with integrated camera and spent 2 h in the museum. They were asked to send at least six pictures and/or notes to the person in the HomeLab.

The HomeLab participants took part in a conventional usability test. They were given a list of tasks to perform and were interviewed about their experiences with the interface. Afterwards, they were asked to simply check the ASTRA device occasionally for messages of their family members or friends. When the other participants returned from the museum, the HomeLab participants were asked to explain the system to them (see Fig. 7). This protocol was inspired by the ‘peer tutoring’ method [21] developed for children, which creates a context for verbalization that is more natural than think-aloud protocols. Our intention was to capture verbal data that would help us understand how our test participants understood the system.

**Fig. 7** **a** Camera facilities at the HomeLab provide video material to support qualitative evaluation. The person who stayed at the lab explains to the ones who went to the museum how the home device works. **b** Kids interacting with the interface



Adults were asked to complete the two questionnaires described in the next section. The session ended with the researchers facilitating a group discussion to obtain qualitative feedback about participants’ experiences and opinions.

### 5.3 Measures

Two tools were used to assess connectedness and social presence experiences. The IPO Social Presence Questionnaire (IPO-SPQ), named after the institute where it was developed, is a questionnaire designed to assess the level of social presence in synchronous communication tools [12]. The IPO-SPQ combines two approaches to measure social presence. It uses the semantic differential items from [11] that measure affective qualities of the medium, e.g., “impersonal–personal”, “cold–warm”. It also includes subjective attitude statements using a 7-point agree–disagree scale, e.g., “To what extent did you have the feeling that you had a real meeting with your family members” and “Did you ever have the feeling of being able to touch your family members?”

To measure the benefits and costs of communication, we used the ABC questionnaire described above. The set-up of this laboratory test did not include bi-directional communication, which is assumed by the ABC-Q. Thus two items of the ABC-Q, which were not applicable to the set-up of this test, were removed from the questionnaire.

### 5.4 Results

#### 5.4.1 Usability and technical issues of the home device

The observations from the usability test at the HomeLab, the verbalization data obtained during the peer-tutoring component of the test and the interview data were analysed to identify design defects. We looked, for instance, at the number of actions that participants needed to find a specific functionality and how they later explained a specific functionality to their friends or family members. It was concluded that participants found the interface easy to understand and use.

They could complete most tasks without diverting from the optimal path. All participants were confident that they would be able to use the system immediately or after a short practice period.

Examples of usability problems included troubles finding availability information, a few unclear icons, and a system response time that was sometimes found to be too long.

When asked what they liked about the interface, participants mentioned that the spiral looked pleasant and gave a good overview. They appreciated the fact that they could influence which pictures were displayed in the spiral and they could easily view pictures in the full-screen or the slideshow view.

#### 5.4.2 Use of the mobile device

On average, participants at the open-air museum sent 12 pictures, which are more than the minimum of 6 pictures, which was requested. In the focus group interviews, participants indicated that they thought sending pictures was quite easy and they liked the feeling of showing their experiences to the person in the HomeLab. Four out of five groups of participants used the telephone to call each other; during these conversations all of them talked about the pictures.

#### 5.4.3 Social presence and affective benefits and costs

Participants completed both the IPO-SPQ and the ABC-Q. However, we feel that the HomeLab set-up was not ideal for assessing social presence and affective benefits and costs. First of all, there was no baseline or control group against which to compare the obtained score, which makes it very difficult to draw conclusions. Secondly, both questionnaires assume two-way interaction, which was not present in this set-up. Finally, we cannot assume that the communication, which took place during the test, can be attributed to genuine communication needs. Rather it was a task set to them by the experimenters, which makes it difficult to evaluate perceived benefits and costs.

The IPO-SPQ results show that participants did not experience very high levels of Social Presence. The ABC-Q results indicated that participants had some feelings of obligations and expectations; which is not surprising regarding the structured nature of the task given to them. Participants did not feel the system strongly threatened their privacy. In the focus group interview all participants indicated that they enjoyed the sharing of pictures to keep each other up to date. Scores on the Connectedness and Recognition scales were somewhat low.

From the interviews, it was clear that although participants liked to share their experiences, they did not feel a particular need to use an awareness system like ASTRA. This may be due to the short time that they used the system and the artificiality of the experimental

situation. Participants sent some pictures because we instructed them to and not because they felt a genuine need to communicate. Further, the communication they experienced with the system was one-way only.

The conclusions of this laboratory study confirmed the necessity of executing a field study. The system should be assessed over a longer period of time, in a more realistic environment in which tasks are not set for the sake of the assessment only. In the field experiment described in the next section, we tried to adhere to these principles.

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## 6 The field experiment

A field experiment was conducted to investigate the user's experience of ASTRA in the context of daily life over a reasonably long period of time.

### 6.1 Participants

The experiment involved studying two pairs of families, for 2 weeks each. Each of the families involved resided in a different city of the Netherlands, so they were separated by distance. Families are described below in terms of their town of residence: Amsterdam and Bilthoven for the first pair and Oldenzaal–Rotterdam for the second. The families participated out of interest, but received a financial reward as well.

### 6.2 Procedure

We used a within-subjects design consisting of two phases lasting a week each. In the first week we observed the normal communication between the two households by means of a diary and an interview and assessed the experience by administering both questionnaires (IPO-SPQ and ABC-Q). We used the same diary as in the requirements study that was previously described (Sect. 2.1).

In the second week of each test, ASTRA was introduced in both households and used for one week. Each household received one home device and one mobile device, which they had to share. We used the same data collection techniques as in the first week, plus logging the usage of ASTRA. At the end of the second week we conducted a focus group to obtain more information about their experiences with the system.

With this set-up we aimed to compare the 2 weeks and to see the effects that the ASTRA system would have over the results of the questionnaires and diaries. With the logged data we wanted to uncover different ways of using the ASTRA system.

### 6.3 Results

In the first test, ASTRA was used for 1 week with only some minor technical problems. In the second test,

however, ASTRA could be used for 4 days only because of technical difficulties. In the first test, 90 messages were sent (28 to Amsterdam and 62 to Bilthoven). In the second test, participants sent 69 messages (42 to Oldenzaal and 27 to Rotterdam). On average, 13–17 messages were sent per day.

In both tests, participants used the home device more in the first days of the tests and less towards the end. This can be attributed partly to the first 2 days being a weekend where participants had more time and partly to the novelty wearing off after this time. Considering each household had only one mobile device, so that only one person was supplying input, there was still a remarkable usage of the system.

The pictures that participants took with the mobile device show a variety of topics, generally concerning everyday events but also more special events such as a birthday party. Sometimes long explanatory handwritten notes accompanied the picture. Somewhat unexpected was that participants had “conversations” by pictures. For example, they would send a reaction to a picture that showed a new pair of sport shoes purchased that afternoon or after receiving a picture of an almost empty glass of beer (see Fig. 8). Also, we noted that while in the beginning participants attempted to be artistic and to compose nice pictures for sending to the other household, over the week they reverted to quickly snapping an image for the purposes of sharing a moment with the family connected to them. In the interviews, participants confirmed that sharing moments was very valuable to them, because it allowed them to show and see parts of each other’s daily life that are normally not accessible. The decision to share a moment is often taken on impulse; several participants described that they took a picture but had to delay sending it because they were interrupted, and afterwards decided not to send it after all. So, importantly, the need to share seems to diminish when the moment itself passes. The instantaneous sharing of socially significant moments is exactly what ASTRA enables users to do.

#### 6.4 Social presence

Overall, higher levels of social presence were experienced in the second week, but the difference between the overall IPO-SPQ scores was not significant (see Fig. 9).

In contrast to earlier studies in which the IPO-SPQ has been used, we found only moderate correlations between the semantic differential scores and the subjective attitude scores constituting the IPO-SPQ ( $r = 0.67$  in the first week and  $r = 0.45$  in the second week). The Wilcoxon signed rank test was used to check for significant differences between Social Presence scores in the first week and the second week. Scores on the subjective attitude statements were significantly higher in the second week than in the first week ( $Z = -2.20$ ,  $p = 0.03$ ). For the semantic differentials there was no difference between the weeks.

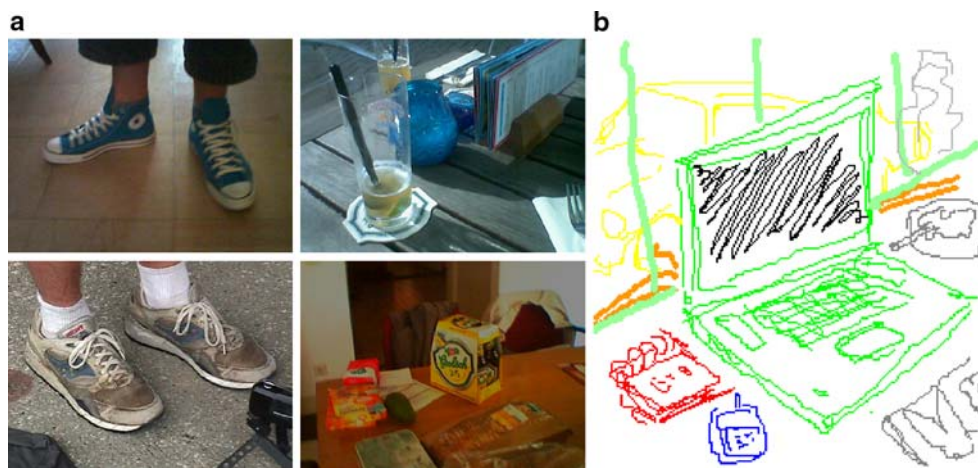
#### 6.5 Affective benefits

The mean scores for all scales of the ABC-Q are shown in Fig. 10. The Wilcoxon test was used to test for significant differences between scores.

The following results were found:

- The scales of ABC-Q relating to obligations, expectations and privacy (the ‘costs’ associated with communicating through the ASTRA system) do not differ significantly between the first and the second week.
- Participants thought about each other more often in the second week, when they were using ASTRA ( $Z = -2.67$ ,  $p = 0.008$ ).
- Their awareness of the situation of their family members was much higher ( $Z = -0.231$ ,  $p = 0.021$ ).
- They indicated they felt more connected to each other in the second week ( $Z = -2.02$ ,  $p = 0.043$ ).
- They felt they were sharing more experiences with each other ( $Z = -2.38$ ,  $p = 0.011$ ).
- The perceived level of group attraction was higher in the second week ( $Z = -2.23$ ,  $p = 0.026$ ).
- The recognition was slightly higher in the second week but this difference was not significant.

**Fig. 8** **a** First column: new–old shoes reaction; second column: an almost empty glass–full pack of beer. **b** Artistic drawing



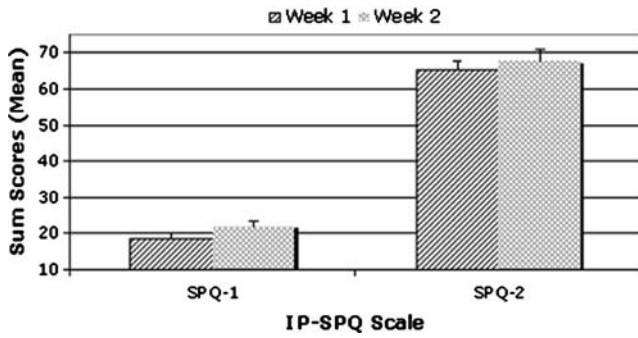


Fig. 9 Mean scores on the IPO-SP Questionnaire in the first and the second weeks of the field test. SP1 is the score for subjective attitude statements; SP2 is the score for semantic differentials

The results of the questionnaire suggest that the participants experienced significantly higher affective benefits when using the ASTRA system, without experiencing additional costs.

### 6.6 Qualitative data: interviews and diaries

The diaries did not work as well as in the requirements study. In the first week in which participants did not use ASTRA, diary-keeping went quite well. In the second week participants started sending a lot of pictures and did not have sufficient time to describe every contact. Some wrote a summary in their diary at the end of the day; others did not keep a diary at all in the second week. Clearly, the sampling protocol for the diary is not appropriate when informants are expected to record a multitude of fleeting interactions with a system.

#### 6.6.1 General experience and future use

The interviews and diaries show that participants were very enthusiastic about their experience with ASTRA,

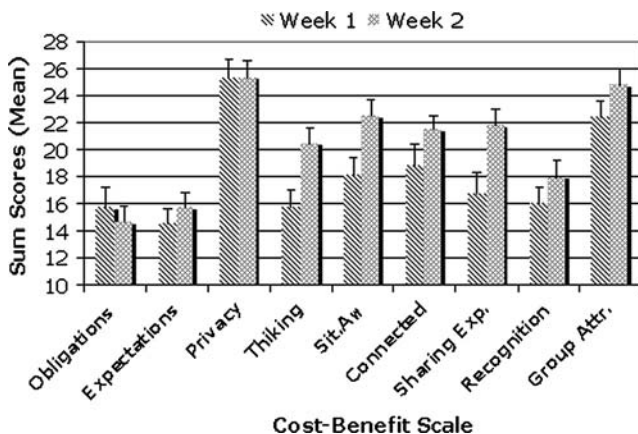


Fig. 10 Mean scores on the ABC Questionnaire in the first and the second weeks of the field test. Each scale has a minimum value of 4, and a maximum value of 28

despite the occasional technical problems. Several participants reported that they had not expected to use the system a lot, but became convinced of its added value throughout the week:

“I thought it would just be nice to try it out for a week. I never expected I would want to use it afterwards. But now, I feel really sorry that it has to go.”

Out of 11 participants 7 indicated that they would like to use the ASTRA system in their daily lives. Others said that although they liked the system, they needed more time to ‘find a place’ for it in their daily lives and communication patterns. Several participants predicted that they would probably use it less if the novelty wore off. They would also like to involve more people in this kind of communication, such as their friends and other relatives.

#### 6.6.2 Influence of media usage

Participants differed in opinion as to how ASTRA would influence their usage of other media. Some participants thought that they would use them less, because ASTRA could be a partial replacement.

“For some occasions it could replace the phone, e.g., general calls just to show interest or let them know you are thinking about them.”

Other participants saw ASTRA as an extra possibility, which would not influence their contacts with other media. Some participants, finally, thought that ASTRA would increase their usage of other media.

“I would use the phone more often, out of curiosity.”

Nearly all participants believed that ASTRA would change the content of (some of) their contacts by other media or real meetings.

“You need less time/formalities to start the conversation, because you know more about each other’s context.”

#### 6.6.3 Sharing experiences

Users reported that ASTRA allowed them to share experiences with each other that they normally did not share because of time shortage or lack of suitable media. They reported that sending a picture did not take much time and effort.

Although the pictures and messages they exchanged were often quite trivial, they succeeded very well at generating a *feeling of connectedness* between the households. Participants became more aware of the activities and well-being of their family members. The pictures had the effect of making them curious.

“On the one hand it is a shallow way of communication, but you get a lasting sense of what the others are doing.”

Participants mentioned that they liked the *surprise effect* of new pictures appearing on the screen and the feeling of being informed about events in the lives of their family members.

#### 6.6.4 *The need to react*

Of course, there were also some things that participants missed or did not like about ASTRA. One of the main comments was that it does not sufficiently support sending a reaction. Future work should try to improve this aspect of ASTRA. In the first test (the usability test in the HomeLab) this was understandable because the reply function did not work yet. But in the second test (the field test) participants still indicated that this was not enough for them, because replies can only be sent between the home devices. Apparently, people have quite a strong need to get/send an immediate reaction to a picture. This confirms the design rationale of the prototype awareness system designed and reported in [16], which aimed to support a quick reaction to items shared by connected individuals.

#### 6.6.5 *Privacy versus shared spaces*

The option to send messages to individuals rather than the whole household was hardly used; almost all messages were sent to households. One reason for this was that pictures sent to individuals were rated as less accessible because users have to go to their personal space to see them, whereas pictures for the whole household automatically show up on the household screen. Another reason was that participants did not feel the need to use this functionality.

“I only need privacy for deeper communication and I use e-mail for that. I wanted to send my pictures to everyone.”

Part of the rationale behind the personal spaces is not only privacy, but also to prevent information overload; some messages may simply not be interesting for all household members. In this study where only two households and two mobile users were connected at any time, participants were not exposed to this problem so did not have a need for the solution to it.

#### 6.6.6 *Obligations*

Participants indicated that ASTRA did not create new obligations. Taking a picture and sending it does not take a lot of effort and therefore the receiver does not feel compelled to respond. Both the sending and the receiving of ASTRA-messages can be done in a short

time; therefore participants could blend it in with their daily lives.

“It is non-committal. If someone sends you a long e-mail you have to respond to it, but not to just a picture.”

#### 6.6.7 *Target families*

Because of the interviews and the diaries in the first week, we had information about the existing relationship and communication between the households. We noticed remarkable differences in communication patterns. In the second family there are no substantial communication problems. They see each other regularly, use phone, e-mail and chatting almost daily to stay in contact and are very much up-to-date about events in each other's lives. In the first family, however, the situation is different. Both households feel very close to each other, but because they all have very busy lives (jobs, and the family in Amsterdam has young children) they do not see each other often. They stay in touch by using e-mail and the phone, which is sometimes sufficient but sometimes not. In general, they know about important events but are not very up-to-date about each other's daily experiences.

From all interviews, we received strong indications that the first family experienced more added values from ASTRA than the second family. They had more contact than usual and the pictures showed them parts of each other's lives that they normally do not know about.

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## 7 Summary of results

Though it is hard to extrapolate from studying two pairs of families for just 2 weeks, the results are very promising. More confidence on our results could be obtained by a broader study, where a larger part of one's communication activities and with a larger component of one's social network could be included in the test. Further studies should allow more individuals of each household to be equipped with the mobile device and the experiment to run at least over 2 weeks.

The results of the field test confirm that the ASTRA system can help related distributed households to stay in touch with each other. Participants reported thinking more about each other, having higher situation awareness, connectedness, sharing experience and group attraction when using ASTRA. These are valuable affective benefits and were experienced as hypothesized in the outset of the project.

Busy families like the one studied can be served quite well by lightweight, asynchronous systems designed for sharing experiences. This was a rather unexpected finding as we originally did not have such a target user group in mind. Further testing should explore whether a system like ASTRA is equally valued by elderly people living alone and the role it can play in the communica-

tion of such individuals with their close family and friend.

Participants indicated that the regularly incoming messages fostered a lasting sense of awareness about members of the other household and helped them to feel more involved in each other's lives.

From this research we can now provide some answers to the questions formulated in earlier sections. Social presence as mentioned above does not seem the right concept for studying awareness systems. It seems that it is a sensation that is experienced also through awareness systems, but after our experience with ASTRA we believe that this observation rather misses the point. Awareness systems deliver and are targeted to attaining the feeling of being connected with other people, of not being alone, of being involved in each other's lives, etc. The ABC questionnaire seems a credible yardstick for the success of communication media to achieve connectedness, especially in the sense of affective awareness as discussed above. This yardstick needs to be developed further especially to cover issues of effort relevant for characterizing peripheral awareness.

Regarding the implementation, we have only implemented sufficient functionality to enable the laboratory and the field tests. We plan to extend connectivity to more people, in various directions (home–mobile, home–home, mobile–mobile) and especially to provide automatically maintained, moment-by-moment awareness information. This will serve as a test-bed to study from a social perspective the privacy issues that are related to the use of more pervasive technology that can support and, maybe, enhance the benefits reported in this study.

Within the domain of awareness systems we have provided several advances. While other works, e.g., [14, 18, 21] discussed in the Sect. 1 have focus on connecting two households, we also connect mobile household members. This is a necessary step to go beyond awareness of a place and to achieve awareness of persons. Also ASTRA addresses directly the need to embed awareness systems within the range of communication services offered to consumers.

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## 8 Conclusion

Considering the wide array of communication devices that people have at their disposal in our Western society, it is remarkable that individuals are often having unmet communication needs. The combined diary and interview study we reported above has shown that often communication requires a practical pretext to happen—people, especially males, communicate little for social purposes although these are the types of communications they value most. In trying to articulate the nature of the needs and the corresponding affective benefits that mediated communication can provide we formulated the concept of Connectedness.

Connectedness describes in a medium-independent way the feelings of being in touch with someone, being aware of what happens in their lives, feeling they think and care about you as this results from a phone call, a mail, or any form of communication. It also pertains to the need to be informed about them that grows with the frequency of communication and it brings about some costs, e.g., the feeling of being monitored or of having to communicate. These dimensions of connectedness reflect typical feelings and situations surrounding our every day use of communication media. Nevertheless, current media theoretical constructs such as Social Presence, do not attempt to describe them focusing mostly on the momentary sensations experienced through communication media. In trying to assess the added value of a novel communication medium, especially with respect to its fit into every day life and patterns of communication, Connectedness seems a valuable concept and the ABC-Q questionnaire developed for its measurement seems a very valuable and generic instrument that can apply to compare media such as e-mail, instant messaging, etc.

We have described ASTRA, a prototype lightweight messaging system that provides awareness of closely related family and friends through lightweight picture- and handwriting-based messaging. It was designed to provide a background channel of information that complements existing media. Our implementation was very limited in that only a small number of people were connected and we did not construct an awareness display also for the mobile user. Nevertheless, the prototype managed to deliver measurable benefits to its users despite the small scale of the study.

The experience of designing and evaluating ASTRA shows that it succeeds in addressing a specific communication need that is currently unmet. Passing, daily events that are perhaps considered trivial slightly after the fact are more likely to be shared enriching the communication between users. A longer-term and more extensive study of communication patterns relating to a system like ASTRA would help verify whether indeed this is the case, even after the first days of using a novel system.

Several limitations but also positive findings in our study are related to its small scale. Clearly, if a system like ASTRA would be used over longer periods and to connect to more people, some degree of automation is needed to provide the almost continuous trickle of awareness information to one's friends and relatives. Directly related to this development are privacy costs; these were found to not be adversely affected with the use of ASTRA where communication was only explicitly triggered by its users. Our current research aims to explore interaction mechanisms that will support users of awareness systems meet their privacy needs.

To summarize, the current study contributes to the field by providing quantifiable evidence of affective benefits that to this point have only been hypothesized. It constitutes a first real-life deployment of an awareness system for the home environment that will connect also

with mobile users; given that people are away from home, this is an essential step in providing true awareness of other people and their activities. Finally, we have shed some light into the nature of Connectedness, its different aspects and its relation to the concept of Social Presence.

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