

From Awareness to Connectedness: The Design and Deployment of Presence Displays

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ABSTRACT

Computer displays can be helpful for making users aware of the remote presence of friends and family. In many of the research projects that have explored the use of novel displays, the real goal is to improve a user's sense of connectedness to those remote loved ones. However, very few have leveraged a user-centered design process or empirically studied the effects of using a display on users' sense of awareness and connectedness. In this paper, we present our multi-phase, user-centered design process for building displays that support awareness and connectedness: Presence Displays, which are physical, peripheral awareness displays of online presence of close friends or family. We present evidence, from a 5-week long field study, that these displays *provide significantly better awareness of and connectedness* to a loved one, than a traditional graphical display of online presence.

Author Keywords

Awareness; connectedness; peripheral display; field study

ACM Classification Keywords

H5.2. [Information interfaces and presentation]: User interfaces – User-centered design; Evaluation/methodology.
H5.3 [Information Interfaces and Presentation]: Group and Organization Interfaces – Asynchronous interaction

INTRODUCTION

Awareness has been defined as “the state of knowing about the environment in which you exist; about your surroundings, and the presence and activities of others” [26]. Various types of information can provide a sense of awareness. For example, looking up the Dow Jones Industrial Average can provide someone with an awareness of the nation's economy while glancing at the window can inform one of the weather outside. For a number of years, researchers have been exploring how to support awareness of remote presence or activity in the workplace [6,9,12,14,20,22]. Evidence has shown that background

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awareness for both co-located and distributed groups can increase work productivity and efficiency [12]. The importance of this awareness goes beyond the workplace.

More recently, there has been an increased focus on supporting awareness in the home [1,3,5,7,11,12,19,26]. While a number of novel domestic systems have been built, very few of them have used a thorough design process or been studied to determine whether they succeed in supporting awareness. Further, in domestic environments, awareness is often a means to an end, with researchers actually being interested in how to support increased feelings of connectedness between people [1,7,12,19,24,25].

Connectedness is defined as “a positive emotional appraisal which is characterized by a feeling of staying in touch within ongoing social relationships” [12]. Connectedness is a social affordance that has been mostly neglected in the development of computer-mediated communication [1,24]. While many research projects have explored the issue of connectedness, only a few have empirically examined the effects of their approach on connectedness [3,19,26]. However, these projects used only subjective measures such as anecdotal and self-reported evidence to show that their approach improved users' feelings of awareness and connectedness. Additionally, they had components that required active, focused interaction to support awareness and connectedness. We build on this past work by using both *subjective and objective* measures to show that these types of displays can improve awareness and connectedness. Furthermore, instead of using focused interactions, we are interested in peripheral displays of information, where no focused interaction is required and, instead, users can focus on other tasks while monitoring information in a cognitively lightweight manner.

Our goal is to build a display of remote presence for domestic environments that supports both awareness and connectedness and to conduct an evaluation showing its ability to support these using both subjective and objective data. Our contributions in this paper are twofold. Our first contribution is a multi-phase, user-centered design process intended to create displays focused on both awareness and connectedness: *Presence Displays*, which we define as physical, peripheral awareness displays of online presence of close friends or family. While we apply this process to a

particular target user group, it can be applied more generally for building awareness displays for other populations. While other groups have used user-centered design process in the creation of their peripheral awareness displays, there are few reports on these processes. Our work is distinct in that we 1) describe our process in detail and 2) describe how our multi-step design process resulted in a set of designs to build. This leads to two sub-contributions, in a community which still knows little about how peripheral displays can be designed to meet user needs and wants. First, our iterative approach helps to validate that our displays and other similar ones do help meet user needs and wants. Second, our process can be used by others to build peripheral displays for similar or different communities.

Our second contribution is solid qualitative and quantitative evidence, from a 5-week long field study of Presence Displays, that these displays support both significantly better awareness of a remote friend or loved one *and* a significantly stronger feeling of connectedness to that person, than a traditional graphical display of online presence. In particular, awareness and connectedness were significantly more highly correlated, and scores on both subjective and objective measures were significantly higher when the display was present than when it was not. Qualitatively, a key result of our study was that the continuous sense of awareness from our displays led to user's learning about a friend or loved one's daily routine. This in turn led to an increased sense of connectedness.

Online Presence

We chose to focus on providing an awareness of online presence because users find tremendous value in this information, even when it is not accompanied with rich media [7,17] or when they are not interested in interacting with others [21], and many believe that it is sufficient for achieving connectedness [17,21,24]. Online presence information indicates whether one is on the Internet or not. Typically, online presence status includes: *available*, online and actively using the computer; *idle*, online but not actively using the computer; and *unavailable*, not on the Internet. Online presence information is easy to gather without significant instrumentation as it is available through any number of instant messaging (IM) applications. IM usage is widespread, with 53 million American adults using IM, and 77% of those using it in the home [27]. As part of some earlier work, we conducted 2 focus groups with a total of 15 participants to learn how people use awareness and IM information [anon.]. We discovered that most of our participants used IM applications as a way of maintaining an awareness of their "buddies", and not just for communicating with them. They also suggested that awareness information should be provided away from their computer in a peripheral manner, using methods that are less distracting than current applications.

Based on these results and our interest in exploring the link between awareness and connectedness, we identified the following hypotheses:

- H1. *Presence Displays support better awareness of presence information than traditional GUI-based presence displays.*
- H2. *Correspondingly, Presence Displays help the user to feel more connected to the remote friend or loved one whose activity is being displayed.*

Overview

In the next section we will present the rich user-centered design process that we followed for eliciting information about how best support awareness and connectedness and for creating our Presence Displays. Previous work has shown that without a thorough well thought out design process, it is difficult to achieve measurable behavioral differences from a field study of a peripheral display [17]. Most of the work in this area has focused on exploring novel concepts for awareness interfaces. Instead, we conducted contextual inquiries and a cultural probe exercise to understand how users maintain an awareness of and connectedness to remote friends and family, and to gather information about the possible form, function and location of Presence Displays. From this, we created a set of 10 different display ideas and conducted an online focus group to collect reactions to and critiques of these displays. We used the results of the focus group to select which displays to build (AugmentedMirror and PictureFrame), and we describe our implementation of these displays and a supporting software system. We follow this with a discussion of our 5-week long field study of these displays where we found that the displays supported both better awareness of a remote friend or loved one *and* stronger feelings of connectedness to that person. We end with a discussion of the related research that has motivated our work and our planned future work and conclusions.

USER-CENTERED DESIGN OF PRESENCE DISPLAYS

In this section, we will present the user-centered design process we used to generate ideas for our Presence Displays and to select which ideas to implement. We chose to work with college students as our target population for two reasons. First, they are early adopters of new technology and use IM the most compared to other adults. They would be most open to using new awareness technology. Second, many of them have recently moved away from home for the first time to attend college, have strong desires to maintain connections to friends and family and use IM to retain a sense of closeness [4]. All of our subjects were between the ages of 19 and 24, and were from a range of departments other than that of the authors'. In the remainder of this section, we describe the user-centered process we conducted with college students to design our displays.

Contextual Inquiries of Target Users

Our design process began with a contextual inquiry of 5 undergraduate college students (4 female, 1 male), where the purpose was to understand how target users maintain an awareness of and connectedness to friends and family. Subjects for the contextual inquiries and for subsequent phases of our work were recruited through online

community (both local to our campus and city) bulletin boards and paper flyers. None had any involvement with our research, other than the participation described in this paper. Subjects did not receive any payment for these inquiries. We conducted the contextual inquiries in the home environment of each of the subjects. Subjects were introduced to the terms “awareness” and “connectedness” to ensure that they shared a common understanding of these words and were comfortable with them. The subjects showed us personal spaces within their home environment, and within each of these spaces, objects with which they had a personal connection with. We collected information about why objects were placed in specific locations and what or whom the objects reminded subjects of. We also asked how subjects received awareness information in each space and where they communicated with others.

A number of important findings arose from the data we gathered. First, as all of our subjects shared an apartment with at least one other person, their bedroom was the most personal and most used space in the house. Subjects used their bedrooms for living, working and sleeping and the bedrooms contained artifacts that reflected these activities. Because of the multi-purpose use of the space, there was very little available open space and all of the bedrooms seemed quite full. Subjects felt that because they spent so much time in their bedroom, that it was the place where awareness information would be most useful. Additionally, as most of their personal effects were located in the bedroom, subjects felt most connected to friends and family while in the bedroom. Our subjects all showed us similar types of artifacts when asked about objects that convey connectedness. The most common objects were photographs of and gifts from loved ones and friends. In both cases, subjects knew who was in the picture or who gave them the gift and recalled a memory associated with the receiving of the artifact. Despite space constraints in the bedroom, subjects liked to have and display physical objects that remind them of others. Subjects preferred to place these objects in locations peripheral to the main bedroom activities: sleeping and studying.

The results of the contextual inquiry suggest that a display of presence information for our target population should be physical in nature, designed to closely associate another person to the display, placed in the bedroom, provide information in a peripheral fashion and not take up too much space. As our subjects indicated, it would be best to augment existing artifacts rather than introduce new ones.

Cultural Probe Exercise

Next we conducted a *cultural probe* exercise. Inspired by Gaver’s work in using probes to elicit inspirational responses from unfamiliar groups [8], we designed a cultural probe that elicited informative responses about the concepts of awareness and connectedness. We adapted the cultural probe idea to also understand how personal artifacts could be used to convey these concepts and why particular objects evoke a sense of connectedness and intimacy.

Unlike contextual inquiries, probes provide recipients with more time to respond to tasks and questions and to be more reflective in their responses. Cultural probes complement the inquiries we conducted, providing opportunities for probe recipients to be *creative*, and not just *descriptive*.

Our probe, delivered to 7 undergraduate college students (2 male, 5 female), was a package containing a welcome letter, a bound journal, a disposable camera, a set of colored pencils, a pencil and a pen. Participants were given 3 weeks and were paid \$30 to complete 17 tasks in the probe, which included describing a close friend or family member (hereafter known as a *loved one*) as a personal object, how they stay in touch with a loved one, how they are aware and connected to loved one, why they want to maintain a sense of awareness and connectedness to loved ones, what different personal artifacts reminded them of, and where they feel most connected to others. The goal of our probe exercise was to collect responses that inspire the form, function and location of our Presence Displays.

For the most part, the probe responses reinforced our findings from the contextual inquiry. Participants provided photographs of physical objects in response to our questions about form: stuffed animals, small toys, and pictures. Questions about functionality yielded responses ranging from colorful sketches to photographs that represented awareness and connectedness. Most of the photographs of friends, objects and locations were taken in the bedroom, where participants wanted to be aware of friends while lying in bed, studying, and leaving their room.

The results from both our cultural probe and contextual inquiry suggest that:

- displays should be physical in nature, as opposed to graphical;
- display artifacts should present information peripherally, not being conspicuous among the rest of the bedroom artifacts, both as inactive objects and as displays of awareness information; and,
- display artifacts should be small and already exist in the bedroom;
- display artifacts should provide an obvious connection between the owner and a loved one.

The first two results are supported by the literature as well. Greenberg and Kuzuoka built a number of physical displays of awareness information and showed how these addressed many of the problems that exist with GUI awareness systems [7]. In explorations of peripheral displays, both Pederson [22] and Wisneski *et al.* [28] note that humans can monitor both foreground and background information and that displays should leverage more of our peripheral awareness rather than compete for our foreground attention.

Presence Display Concepts

Using the results from the contextual inquiry and the cultural probes as a foundation for inspiration, we generated 10 Presence Display concepts. Our conceptual designs reflected the significant trends we found from our studies:

PresenceStool: plastic stool that changes colors to reflect a loved one's online presence

PictureFrame: picture frame holding a picture of a loved one, that displays a physical icon to current presence

StatusGrid: photo wall in a grid pattern, with colored lights for each photo of a person indicating presence

StuffedAnimal: stuffed animal or pillow that changes color or temperature and vibrates to reflect presence

ScentsOfPresence: small toy that releases different scents providing a reminder of a loved one, when that person's presence status changes

AugmentedMirror: mirror augmented with colored lights and physical icons to indicate loved one's presence

RotatingLights: floor lamp with multiple bulbs that flash in different patterns to reflect a loved one's status

InformationAppliance: augmented displays of information such as thermometers or clocks that use color to reflect presence

Chime: wind chime that chimes at different frequencies to indicate presence status

PhotoDisplay: copy of a personal photograph where the background imagery is replaced with a translucent background that changes colors to reflect changes in presence status

Note that many of our displays use color to indicate presence. This design choice reflects our study participants' strong preferences for unobtrusive awareness displays. Use of audio and visual animation was minimized.

In order to present our conceptual designs of Presence Displays to potential users to gather comments and critiques, each concept included a photograph of the display (often an image from the cultural probe exercise or contextual inquiry that inspired the design), a scenario illustrating how the display could be used, and a description of the display's form and function. As an example, we provide the concept presentation for the PresenceStool:



Description: The PresenceStool is a plastic stool embedded with LEDs on the interior surface so that the stool can take on different colors depending on which LEDs are lit. The status of your friend is indicated by the color of the chair. For example, if the chair was glowing red, this would mean

your friend would be unavailable. Other statuses could include green which could mean "available", yellow could mean "busy", etc.

Scenario: Joe is working in his room on the computer. Out of the corner of his eye, he sees the color of the chair change from clear to green. This signals that he is aware of his friend's digital presence and is currently available. The chair later changes color to red. Joe notices this and interprets this to mean that he is still digitally present but unavailable.

Online Focus Group

In keeping with our user-centered design approach, we wanted to conduct a focus group to collect critical feedback

on our Presence Display concepts and gain consensus on the concepts to implement. We chose to run this focus group *online* and *asynchronously* over a period of several days. Traditional focus groups are in-person and synchronous and have the advantage of all participants understanding the context in which opinions are stated. Our non-traditional focus group also provides the critical feature of supporting interaction between participants that allows them to highlight their views of the world, values and beliefs, to ask questions of each other, and to re-evaluate and reconsider their own opinions [10, 15]. In addition, it is easier to organize (as participants do not all have to come to one physical location at a prescribed time), provides time for reflection beyond initial "first impressions", and allows those participants who are less aggressive to be more vocal.

Our online focus group was executed in the form of a semi-structured web log or *blog*, allowing participants to anonymously respond to questions posed by us and to the responses of the other participants. We had 8 undergraduate college students (6 female, 2 male) in our online focus group that ran over a period of 10 days. When the participants logged into the blog, they saw the 10 Presence Display designs, including images, scenarios and textual descriptions. Each participant was required to write a review of each design, including initial reaction, where they might place it, its impact on their environment, and its ability to convey awareness and connectedness. Participants were also required to respond to at least one other participant's review for each design. Finally, participants were required to reflect on all the designs and rank their top 3 preferred designs with rationale for their choices.

All 8 participants were paid \$30 and successfully completed these requirements, providing us with necessary and useful feedback on our designs. Some designs were almost uniformly rejected. The PresenceStool was seen as taking up too much valuable real estate in the participants' already crowded rooms. The StatusGrid was too difficult to read easily and would stand out in a room because of its large size. The StuffedAnimal's ability to heat up was a safety concern (*i.e.* overheating) to a number of participants. The Chime was seen as potentially quite distracting in situations with a number of quick changes in presence information.

The 3 most highly rated designs (in decreasing order) were the InformationAppliance, PictureFrame and AugmentedMirror. Participants appreciated that the designs were based on objects they already had in their rooms and that the displays were small enough to easily blend into their existing environment. InformationAppliance was the most preferred because participants already looked at clocks and thermometers as part of their daily routine and using this display would modify this routine the least. Although looking into a mirror while getting dressed is also a part of one's daily routine, the PictureFrame was rated higher because of the simplicity of its design and the perceived ease of use in interpreting a visual icon as opposed to a color on a mirror frame.

As part of the online focus group, we also asked participants to reflect on the designs and speculate as to how each design would affect their feelings of awareness and connectedness with a loved one. While all the participants agreed that every design would raise their level of awareness, they also agreed that some designs would not affect their feeling of connectedness. Of the 3 highly rated designs, participants strongly preferred the PictureFrame and AugmentedMirror over the InformationAppliance for promoting connectedness. They thought the PictureFrame would always make them think about the person in the picture. For the AugmentedMirror, they would see themselves and the presence status of a loved one, evoking a feeling of co-presence and connectedness. But, the InformationAppliance did not promote connectedness, being based on objects like clocks and thermometers.

We asked a follow-up question to better understand this issue: “If we added a picture of the friend or loved one to the InformationAppliance, would it be better at promoting connectedness?”. A large majority of the participants said that it would not, because the appliance naturally displays information that is not related to a person, unlike the picture frame and mirror. The participants agreed that if the physical object being leveraged in the display does not have an inherently human or personal aspect to the information it presents, it would not be likely to promote a feeling of connectedness with another person.

PRESENCE DISPLAYS: PICTUREFRAME AND AUGMENTEDMIRROR

Based on the results of our focus group, we decided to implement the PictureFrame and the AugmentedMirror, the 2 most highly ranked designs that were thought to support both awareness and connectedness. In this section, we discuss the implementation of these displays.

PictureFrame

The PictureFrame Presence Display is an ordinary picture frame augmented to display information about a loved one’s remote presence (Figure 1). Motivating the idea to augment a picture frame is the observation that most picture frames hold the picture of the owner’s family or a loved one. The current design allows the user to map the Presence Display to a single loved one and to make this mapping more explicit by placing the loved one’s photograph in the frame. The 5 by 7-inch frame size allows the client to be easily placed on a desk or shelf. As opposed to other designs that draw attention to themselves by their striking appearance, the PictureFrame is meant to blend into the user’s environment with other household artifacts.

The PictureFrame displays the loved one’s online presence information through visual icons, similar to those found in IM clients (e.g. open door for *available* status, closed door for *unavailable* status, notepad for *idle*, and AOL IM logo for *text message arrived*). All the icons are attached to a physical wheel, connected to the rear of the frame, so that only one icon is visible at a time. A Phidget Servomotor

[10] controls this wheel to display the appropriate icon when presence information is received through a USB cable that connects the display to a networked computer.



Figure 1: PictureFrame Presence Display. Initial design shown to focus group (left) and implemented display.

The icons used were taken from graphical user interfaces of existing Instant Messenger (IM) clients in order to leverage a user’s familiarity with the images. By using familiar icons, we believe that users will be able to understand a loved one’s presence status at a glance. Our focus group participants suggested that we remove the background IM frame and text and use a simpler representation in a solid colored frame. Therefore, we removed some of the IM graphics in our final design (Figure 1, right)

AugmentedMirror



Figure 2: AugmentedMirror Presence Display. Initial design shown to focus group (left) and implemented display (right).

The AugmentedMirror Presence Display is an ordinary 4-inch x 4-inch mirror augmented to display information about a single loved one’s remote presence along its borders (Figure 2). We chose to augment a mirror as it is commonly found in most bedrooms and use of a mirror is part of a daily routine when getting dressed and leaving home. By embedding awareness information into the mirror, our intent is to provide information about a loved one that can be absorbed during the introspective moments when a user is looking in the mirror. Similar to the PictureFrame, the AugmentedMirror is compact and simple in appearance, and can blend into a user’s environment.

The AugmentedMirror displays a loved one’s online presence information by using color. A number of red,

green, and blue LEDs have been attached to the mirror's frame and then covered with translucent paper. When the LEDs are lit, the paper helps to smooth and spread the color along the frame, rather than having light at a few discrete points. The frame glows green when the user's loved one comes online, red when offline and blue when idle. When a text message is sent by the loved one to the user, the LEDs are lit in succession creating a cycling color effect (lasting a few seconds). A simple electronic circuit receives the loved one's presence information from a networked computer connected to it and decides which LEDs to turn on and off.

Software Infrastructure

A common software infrastructure provides a loved one's awareness information to both the PictureFrame and the AugmentedMirror displays. One benefit of the common infrastructure is that it is easy to interchange Presence Displays, from a software perspective. Once the hardware implementation for a display is complete, only a single Java interface needs to be supported, providing code specifying what to do when it receives *online*, *offline*, *idle*, and *text message* updates. A second benefit of our infrastructure is it is completely transparent to the user's loved one, who does not have to use additional software nor do anything other than what they already do, which is to use their preferred IM client when online.

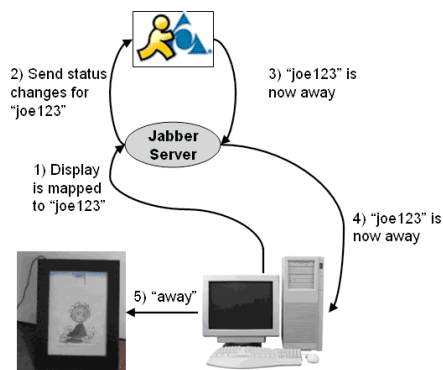


Figure 3: Overview of a display's software infrastructure. In this scenario, a PictureFrame is mapped to a loved one's screenname and is updated when the presence status changes.

Figure 3 shows an overview of this infrastructure. When a Presence Display is started, a customized Jabber® (open-source IM system that connects to commercial IM services) client, written in Java, is instantiated on the networked computer connected to the display. It reads in a pre-specified configuration file containing the IM screenname of the user's loved one, the IM service the loved one uses and the location of an available Jabber server. The client logs onto the server with this information which, in turn, connects to a commercial server corresponding to the loved one's IM service (e.g. AOL). Whenever the loved one's online presence information changes or the loved one sends a text message to the user, the commercial server notifies the Jabber server, which then notifies the local Jabber client. Upon receiving updates, the local client invokes commands specific to the Presence Display (e.g. controlling

the servomotor on the PictureFrame or the LEDs in the AugmentedMirror) to reflect the updates appropriately.

FIELD STUDY

Once we completed the implementation of the PictureFrame and AugmentedMirror, we deployed them in the field for 5 weeks. The purpose of the field study was to investigate the link between awareness and connectedness and to show quantitatively that our Presence Displays provide significantly higher feelings of awareness and connectedness than traditional GUI displays of online presence. We also explored these effects qualitatively through exit interviews with our users. Our hypotheses are:

- H1. *Presence Displays support better awareness of presence information than traditional GUI-based presence displays.*
- H2. *Correspondingly, Presence Displays help the user to feel more connected to the remote friend or loved one whose activity is being displayed.*

Our field study had 9 participants, including 6 women and 3 men. All of our subjects were college students living in shared apartments or houses with other students. All participants were frequent users of instant messaging software. In addition to the GUI-based IM client they already used, 3 subjects were given a PictureFrame to use, 3 were given an AugmentedMirror (with these 6 forming the *display group*) and the final 3 formed our *control group* and were given no additional display. Subjects were asked to select a person they knew to be mapped to their display. The restrictions we put on the selection of this person were that this person must be more than a casual acquaintance and must regularly use a commercial IM client. Some subjects chose friends while others chose family members, and all chosen lived at least a 2-hour drive away. Subjects were paid \$100 for participating in this field study.

Method

We collected self-reported and objective data for measuring awareness and connectedness over a period of five weeks. We conducted a reversal design field study with 3 phases:

- Phase A (week 1): Data was collected while the user did not have a display installed. This phase established the baseline level of awareness and connectedness between the user and the mapped loved one.
- Phase B (weeks 2 to 4): We created a configuration file for each *display group* subject and installed a Presence Display in his/her preferred location: the bedroom. The Presence Display ran during this three-week period.
- Phase A' (week 5): In this final phase, the Presence Display was removed from the user's space. This phase served as a comparison to both phase B as well as phase A. In the latter case, the setup is identical, but the user had experience using the display in the interim time.

Peripheral displays are notoriously difficult to evaluate, as most evaluation techniques draw attention to a display, making it no longer peripheral [22]. To combat this, in each

of the phases, we used an experiencing sampling technique to collect information from users at random times of the day. The sampling is infrequent enough that users will not want to or be able to pay constant attention to the display in order to answer the questions posed. When phase A began, we installed our experience sampling software on the users' home computers. This software caused a survey to pop-up on the user's computer 6 times a day at times when the user was actively using her computer (defined as any keyboard activity in the previous 30 seconds). The survey consisted of 6 multiple-choice and Likert-scale questions including:

1. Select your loved one's current online state: away, idle, available, offline
2. How many status changes have you observed since the last pop-up survey?
3. How aware are you of your loved one's status?
4. How connected do you feel towards your loved one at this moment?

We logged the loved one's status changes throughout the entire study, allowing us to verify each user's responses to questions 1 and 2. In phase B, the software caused the deployed Presence Displays to go into a "blank" state, where they conveyed no information, before the pop-up survey covered the user's entire display. This forced users provide answers based on their memory and perception, rather than using the Presence Display or IM client.

Each evening, our users were also asked to respond to an online survey. The survey contained similar questions to the pop-up. The online survey allowed us to collect data on days when a user was not at their computer very much.

After the 5-week deployment was completed, we conducted an in-person interview with each user. The topics covered in the interview were on how a user used the display, the impact the display had on a user's sense of awareness and connectedness with his loved one, and any modifications the user would like to see made to the display.

Data Analysis

For each of our hypotheses, we ran a number of tests, to be executed on the data in each phase, to determine whether it should be confirmed or not. We did not find any differences between the 2 groups using the different Presence Displays, so we focused our analysis on the differences between users with a Presence Display (*display group*) and the users without one (*control group*).

H1. *Presence Displays support better awareness of presence information than traditional GUI-based presence displays.*

We looked at objective and subjective measures of awareness. Objectively, we scored the user based on how accurately they reported their loved one's current status and number of status changes on each pop-up questionnaire. We also asked the user to self-report his or her level of awareness on each pop-up questionnaire. We then studied the effect of condition (display/control) and phase of study (A/B/A') on all three of these dependent measures.

H2. *Correspondingly, Presence Displays help the user to feel more connected to the remote friend or loved one whose activity is being displayed.*

We compared subjective measures of awareness and connectedness. We asked users to self-report their level of connectedness on each pop-up questionnaire, and correlated this with reported levels of awareness. We also studied effects of condition and phase of study on connectedness.

Analysis Results

The effect of introducing a display on awareness and connectedness was analyzed in an analysis of variance with the phase (A, B, and A') as a within subjects factor. Specifically, we measured self-reported awareness and connectedness and scores on reporting current IM status of buddy and number of recent changes of buddy status. We initially included the control group, with condition as a between subjects factor. Figure 4 shows the noticeable increase in both self-reported awareness and connectedness when the display is introduced. While we have statistically significant results for awareness and the status scores, due to the small number of control group participants (3), our connectedness results are not statistically significant.

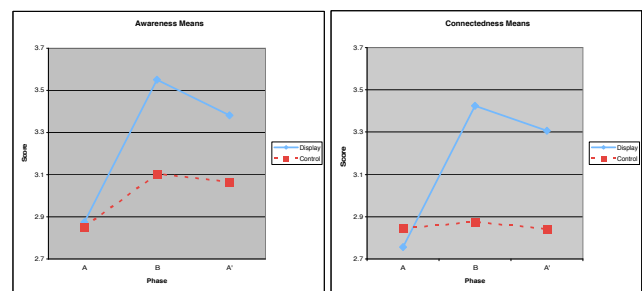


Figure 4: Means of awareness and connectedness for the display and control conditions through phases A, B and A'.

For this reason, we conducted an analysis of variance that focused solely on the six participants who received displays, again with phase as a within subjects factor. Our analysis used the same measures mentioned above, across all phases. The main effect of phase was significant, Wilk's $\Lambda = .015$, $F(10, 12)=8.699$, $p < .001$, partial $\eta^2 = .879$.

The significant main effect for phase was analyzed by single degree of freedom "repeated" contrasts. Effect sizes were computed as partial η^2 values. The introduction of the display caused significant changes in connectedness, awareness, scores reporting loved one's number of status changes, and scores reporting a loved one's current status, along with a correlation between awareness and connectedness. For all these measures, it was the change from phase A to phase B that was significant. Table 1 shows the means (average of each user's average) and standard deviations for each of these measures.

Inspection of the data (Table 1 and

Figure 4) shows there was a significant increase in feelings of awareness and connectedness, percentage correct reported number of status changes and reported current status, and the strong positive correlation between

awareness and connectedness from phase A to phase B, but no significant change going to phase A'. In other words, the displays' positive impact did not go away in the week after the removal of the display.

Table 1: Quantitative field study data of display group. All changes in data are statistically significant. Largest values in each row are in phase B, as expected, and are in bold.

	A	B	A'
Hypothesis 1			
Percent correct of reported number of status changes	53.2 SD=12.7	72.2 SD=4.6	69.8 SD=4.2
Percent correct of reported current status	30.3 SD=12.5	69.8 SD=5.0	65.8 SD=20.3
Reported level of awareness	2.87 SD=.30	3.55 SD=.11	3.39 SD=.29
Hypothesis 2			
Reported level of connectedness	2.75 SD=.47	3.43 SD=.07	3.33 SD=.35
Correlation between awareness & connectedness	0.75	0.87	0.79

DISCUSSION

From our analysis of this field study data, we can come to some conclusions on our hypotheses:

Hypothesis 1 is confirmed: Presence Displays are effective at making users aware of loved ones. Having the display provided a significantly greater sense of awareness to users, as revealed by the changes in the subjective measure, self-reported awareness level data, and the objective measure, increased ability to correctly answer awareness questions about the user's loved one, specifically the number of status changes since the last pop-up and the current status. In exit interviews, one user noted "When I had the [presence] display, I was better able to keep track of my friend." Another said "Even after a day, I noticed I could better answer the pop-ups." Removing the display resulted in users reporting lower levels of awareness.

It is interesting to see that the display continued to have an effect even after it was removed, on users' abilities to correctly report status changes (only declined from 72 to 70%). With the display, users were made more aware of a loved one's status and may have learned behavior patterns of the loved one, giving them the ability to better answer status question changes even with the display removed. One display user commented that "I could guess what [my friend's] status was when I woke up in the morning."

Hypothesis 2 is confirmed: Using Presence Displays leads to greater levels of connectedness, and awareness and connectedness are correlated with each other. In particular, this correlation is significantly higher when the display is present than when it is not.

In all of our exit interviews with users from the display group, users expressed increased feelings of connectedness with the loved one whose online presence was being displayed and attributed this increase to a greater feeling of awareness about this loved one. Several stated that the display's output often made them think about what a status

change meant. One commented, "Eventually the [output] meant more than the status....I could guess what it meant, like if she went to class or if she was in bed." Another said about her friend, "We weren't that close before ... but now it's like we're family." A third said, "I feel more bonded with [my friend]. I think we're better friends because of it."

Based on comments from our field study subjects, we believe that there is not only a link between awareness and connectedness but also that awareness led to connectedness for users of the Presence Displays but further studies will need to be run to verify this. In our exit interviews, it was clear that over a short amount of time, users became experts at reading the display. First, they perceived it only as remote presence information. But with more use, they were able to maintain a continuous sense of awareness, allowing them not only to better estimate a loved one's status without looking at the display, but also to associate meaning with that presence information, about what the loved one was doing and his/her routine. All of our users stated that when they noticed a change of status, they thought about their loved one for a moment, as something they could do in a lightweight fashion ("in the back of my mind"). Display group users reported that just seeing the display reminded them of their loved one, whether the display was on or not. This led to increased feelings of connectedness.

RELATED WORK

We will now discuss some of the related work that has directly influenced and motivated this research, in the areas of peripheral display design, connectedness and empirical studies of domestic awareness displays. While the initial designs of a great majority of awareness displays were generated through internal brainstorming among the researchers [2,5,9,17,18,20,22,26,28], some researchers have begun making use of both user-centered and participatory design techniques to motivate designs. The ASTRA system used a combination of diary studies and interviews to generate requirements for the To-Tell system, a messaging system that allows mobile users to serendipitously post messages (including digital pictures, drawings and handwriting) about their daily experiences to a remote family member at home [19]. The Casablanca project also looked at how to support awareness and communication between family members [11]. The researchers took the approach of building early prototypes and experimenting with them on themselves combined with lightweight ethnographies of real-world home settings and focus groups for selecting designs to prototype. The CareNet display also used some semi-structured interviews with target users to understand the domain of caregiver networks and followed this up with roundtable discussions to come up with design specifications for a peripheral display of an elder's health status [3]. While the approaches that these projects take are similar in spirit to ours, our approach is user-centered and participatory design focused, is described in detail for others to use it and our case study

provides a more thorough description of how our multi-step design process resulted in a set of designs to build.

Connectedness is a social affordance, in which there is a relationship between tools like IM that foster a sense of connectedness and the social characteristics of the group using it that enables particular kinds of interactions among group members [1]. In a study of IM in the workplace, Nardi *et al.* found that users employed IM to maintain their sense of connection with others and that they found value in knowing who else was around without wanting to interact [21]. While many have implicitly applied these ideas to awareness devices in the office place and home [2,3,9,14,20,22,28], the Connectedness Oriented Devices [17] and FamilyWare [7] projects examine them directly in the home. Similar to our Presence Displays, their goal is to maintain and enhance relationships through peripheral displays that deliver low-bandwidth presence information.

While there have been several research projects exploring domestic displays of remote presence and activity, only a few of these research efforts have evaluated the effects of these displays on users. We discuss these exceptions and describe how we build on their results. The Digital Family Portrait (DFP) is a picture frame augmented with information about an elder's current and historical daily activity. It is intended to provide value both to the elder and to a remote family member using the portrait by providing "peace of mind" about the elder's well-being. Family members interact with the display to view detailed data. A qualitative study conducted over a period of one year with a single elder-family member pair showed great promise in meeting this goal. The study attempted to measure its effect on awareness and connectedness through self-reports, but this was inconclusive. Anecdotally, participants revealed that they felt more connected to each other with the DFP.

Similar to the DFP, the CareNet Display is also a picture frame augmented with an elder's activity information. Interacting with the display also yields more detailed activity information. The goal of this system is to provide awareness information to local members of an elder's care network. A 3-week long Wizard-of-Oz study was conducted with 4 elder-care network pairs to determine whether the display would positively impact the care network members. Questionnaire data and interview data showed that caregivers felt reduced stress and increased awareness of their elder's daily life. While the authors did not mention connectedness directly, anecdotal evidence reveals that the display improved feelings of connectedness.

Our Presence Display research builds on these systems by using subjective self-reported data to show that our displays improve users' feelings of awareness and connectedness and objective measures to improve feelings of awareness. In addition, Presence Displays are physical and peripheral, requiring (and supporting) no user interaction. This allows us to explore how our displays support awareness and connectedness without having users focus on the displays.

Unlike the DFP and CareNet displays, the ASTRA team analyzed subjective data in a quantitative manner, using the Affective Benefits and Costs (ABC) questionnaire that they developed [19]. To-Tell was deployed with 2 families for 2 weeks (first week without it). When comparing the self-reported ABC results obtained at the end of each week, the authors found that participants felt more aware of and connected to each other when using To-Tell. Our research complements this work by examining peripheral displays that support awareness and connectedness, as opposed to the focused interaction used in To-Tell. In addition, we gathered daily subjective *and objective data over 5 weeks*, a longer period to address concerns about novelty effects.

CONCLUSIONS

The literature is full of descriptions of ambient and peripheral displays of awareness information, but with only a few exceptions, the designs of these displays have not benefited from a user-centered design process and there have been no formal field evaluations that empirically show quantitative changes in awareness and connectedness as a result of their use. Our Presence Display work is the first to demonstrate empirically that users of such displays can experience increased awareness *and* connectedness, using both objective and subjective data. Additionally, and just as important, our qualitative results show that users themselves feel that they are more aware and more connected and help explain why increased peripheral awareness leads to increased feelings of connectedness.

In this paper, we described the rich user-centered design and field evaluation of Presence Displays: physical, peripheral displays of remote presence information. We conducted contextual inquiries and a cultural probe exercise with target users to gain insights about how to support awareness and connectedness. We found that:

- displays should be physical as opposed to graphical;
- display artifacts should present information peripherally, not being conspicuous among the rest of the bedroom artifacts, both as inactive objects and as displays of awareness information; and,
- display artifacts should be small and already exist in the bedroom; and,
- display artifacts should provide an obvious connection between the owner and a loved one.

We used this data to design 10 different concepts and conducted an online focus group to determine which ones would best promote awareness and connectedness. We designed a general software infrastructure that supports all our display ideas and implemented our 2 chosen displays: the AugmentedMirror and the PictureFrame. Judging by the feedback from our users, the user-centered design process we used to generate design concepts was successful. The Presence Display users all reported that they liked their display, and 5 out of the 6 asked to keep using the display.

We conducted a reversal design (ABA) field study of the displays with 9 subjects. We collected self-reported data and objective data about our subjects' awareness of and

connectedness to a chosen loved one. We showed that Presence Display users' experienced significantly increased feelings of awareness and connectedness and, objectively, were significantly more aware of their loved one's status. Exit interviews revealed that the displays enabled better awareness of loved ones leading to better awareness of daily routines and strong feelings of connectedness.

Of course, our study had some limitations. In future iterations, we will increase the length of time over which we conduct the study to gather more longitudinal data and the number of subjects we use. While our user-centered design process focused on (mostly female) college students, it should be broadly applicable to other user populations and we will test how our results generalize.

We would also like to explore and implement other Presence Display design concepts, including concepts that display presence information about multiple loved ones. By field testing these designs in a similar fashion to our study, we will be able to more easily compare and contrast them. With an understanding of which concepts succeed and in supporting awareness and connectedness, we hope to generate design guidelines for peripheral displays of remote awareness. Finally, we want to study the long-term effects of using awareness displays, in particular, to understand how users use them to learn friends' routines over time.

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