Technology Probes: Inspiring Design for and with Families

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ABSTRACT
We describe a new method for use in the process of co-designing technologies with users called technology probes. Technology probes are simple, flexible, adaptable technologies with three interdisciplinary goals: the social science goal of understanding the needs and desires of users in a real-world setting, the engineering goal of field-testing the technology, and the design goal of inspiring users and researchers to think about new technologies. We present the results of designing and deploying two technology probes, the messageProbe and the videoProbe, with diverse families in France, Sweden, and the U.S. We conclude with our plans for creating new technologies for and with families based on our experiences.

Keywords
Computer Mediated Communication, Home, Ethnography, Participatory Design and Cooperative Design

INTRODUCTION
In his book, *Bowling Alone* [22], Robert Putnam laments the loss of "social capital"– the interconnections we have with our family, friends, and neighbors – in American society. People participate in civic affairs less frequently, hardly know their neighbors, and socialize less often with friends. The HomeNet study at Carnegie Mellon [16, 17] indicates that computers and the Internet can contribute to this problem by isolating people from family and friends and increasing their daily stress levels.

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However, this study also suggests that when used for communication, computers and the Internet can play a positive role in keeping people connected – email, instant messaging, and family web sites are just a few of the ways the Internet helps keep people in contact. As a result of these conflicting outcomes, people continue to question the value of computer technology even as it permeates their daily lives more and more [25].

Given this skepticism, it is important to continue to explore if and how technology can be used to support communication with and awareness of the people we care about. In the last several years, there has been an increased interest in both academia and industry in designing technologies for homes and families (e.g. [9, 15, 19, 20]). Such design offers a number of interesting challenges. A huge diversity of ages, abilities, interests, motivations, and technologies must be accommodated. People are much more concerned about the aesthetics of technology artifacts in their home than at work [27], their values may influence their use of technology [26], and playful entertainment rather than efficiency or practicality may be the goal [6].

As part of the European Union-funded interLiving [13] project, we are working together with diverse families from Sweden, France, and the U.S. to design and understand the potential for new technologies that support communication among diverse, distributed, multi-generational families. Using a variety of established research methods from participatory design, CSCW, and ethnography, as well newer methods involving cultural probes [7] and our own technology probes, we have learned about the needs and desires of the families, introduced them to new types of technology, and supported them in becoming partners in the design of new technologies.

BACKGROUND

One of the key objectives of the interLiving project is to experiment with different design methodologies. Each of the authors' organizations has long-standing experience in participatory design [24], which remains the core strategy for the project. However, we each have different experiences and perspectives. Families, and the individuals within them, represent a new user group for all of us. interLiving provides us with the opportunity to examine our differences, draw from our collective backgrounds, and integrate the most effective approaches.

One of our challenges is to develop new participatory design strategies in which family members can actively participate in the design of new technology. A typical HCI approach would be to interview the families, create a design, develop the technology and then test it to see what the families like or do not like. However, we would like to come up with methods that enable families to more directly inspire and shape the technologies that are developed. Our hypothesis is that this will lead to designs that will work better in the long run because they address families' needs and/or desires better.

We do not expect the family members to become designers, but we do want them to be active partners in the design process. If we only use the typical HCI strategy described above, we believe it might discourage active participation by users, as the design concept is already well established by the time the users see it. Their suggestions are likely to relate to details about the user interface and will not be fundamental contributions to the technological design [4].

Our original proposal for interLiving was to distribute 'seeding' technologies into the families' homes, to provide families with ideas about what we would like to develop. We expected family members to critique these technologies and provide us with feedback that would affect our subsequent designs. As the project progressed, we shifted to the concept of a 'technology probe.'

DEFINITION

A probe is an instrument that is deployed to find out about the unknown - to hopefully return with useful or interesting data. There is an element of risk in deploying probes; they might fail or bring unexpected results. In the interLiving project, we chose to use probes to study families because the complex personal and private environments they live in makes it challenging to learn about their needs and attitudes towards technology using conventional HCI techniques.

Technology probes are a particular type of probe that combine the social science goal of collecting information about the use and the users of the technology in a real-world setting, the engineering goal of field-testing the technology, and the design goal of inspiring users and designers to think of new kinds of technology to support their needs and desires. A well-designed technology probe should balance these different disciplinary influences.

On the social science side, technology probes reject the strategy of introducing technology that only gathers 'unbiased' ethnographic data. We assume that the probes will change the behavior of our users - in our case, the character of inter-family communications. On the other hand, we recognize the benefits of collecting data in-situ - we were interested in observing how families' communication patterns and their interpretation of the technology changed over time. On the engineering side, technology probes must work in a real-world setting. They are not demonstrations, in which minor details can be finessed. Therefore, the main technological problems must be solved for the technology probes to serve their purpose.

On the design side, technology probes are similar to Gaver et al.'s cultural probes [7] - kits of materials such as disposable cameras and diaries meant to inspire people to reflect on their lives in different ways. A number of researchers, including ourselves, have used cultural probes to elicit both design inspiration for new domestic technologies and information about the users of such technologies [8, 26]. However, cultural probes tend to involve a single activity at a particular time and are not necessarily technologies themselves. Dunne and Raby's Placebo Project [5] is closer to the concept of a technology probe: they introduce thought-provoking technologies into people's homes for periods of time. However, they do not use the technology to collect data about its own use.

Our technology probes involve installing a technology into a real use context, watching how it is used over a period of time, and then reflecting on this use to gather information about the users and inspire ideas for new technologies. A well-designed technology probe is technically simple and flexible with respect to possible use. It is not a prototype, but a tool to help determine which kinds of technologies would be interesting to design in the future. A successful technology probe is open-ended and explicitly co-adaptive [18]: we expect the users to adapt to the new technology but also adapt it in creative new ways, for their own purposes.

In addition to the technology itself, a successful technology probe requires analysis and reflection about its use during and after the deployment by both researchers and users. There are many ways this could be accomplished, but we selected three based on our previous research experiences and areas of expertise.

From a social science perspective, we were interested in learning how families communicate with each other and how the probes helped or hindered their ability to do so. We used ethnographic interviews with the families in their homes before and after the deployment to gather this information. From an engineering perspective, we were interested in how and by whom the probes were used to support communication, so we instrumented them to log things like dates, times, and actions so that we could reconstruct the usage over time.

Finally, from a design perspective, we were interested in seeing what ideas the probes would inspire for new technologies. Our background in participatory design suggested that low-tech prototyping workshops [24] could help elicit creative ideas. We provided the families with art supplies like paper, clay, and pipe cleaners and asked them to build new communication technologies, inspired by positive and negative scenarios that some of them encountered using the probes.

DISTINGUISHING FEATURES

Technology probes can be distinguished from prototypes or products as follows:

Functionality: Technology probes should be as simple as possible, usually with a single main function and two or three easily accessible functions. Prototypes may have many layers of functionality and address a range of needs, not all of which may even be implemented.

Flexibility: Although technology probes should not offer many functionality choices, they should be designed to be open-ended with respect to use, and users should be encouraged to reinterpret them and use them in unexpected ways. Prototypes are generally more focused as to purpose and expected manner of use.

Usability: Technology probes are not primarily about usability in the HCI sense. They are not changed during the use period based on user feedback. In fact, a deliberate lack of certain functionality might be chosen in an effort to provoke the users. For prototypes, usability is a primary concern and the design is expected to change during the use period to accommodate input from users.

Logging: Technology probes collect data about users and help them (and us) generate ideas for new technology. Logging allows researchers to create visualizations of the use of the probes, which can be discussed by both users and designers. Prototypes can collect data as well, but this is not a primary goal.

Design phase: Technology probes should be introduced early in the design process as a tool for challenging pre-existing ideas and influencing future design. Prototypes appear later in the design process and are improved iteratively, rather than thrown away.

IMPLEMENTATION

In the interLiving project, we have discussed developing a variety of technology probes. Such probes can be used by individuals, groups of family members or everyone in the family. They may be designed for the home or settings outside the home. They may be fixed or mobile, hard-wired or wireless, large or small, new or existing. The main criteria is that they be different enough from commonly available technologies that they provoke families to consider how they do or don't fit into their lives.

We have developed and installed two technology probes: the messageProbe and the videoProbe, described in the next two sections. Each was designed to gather data about a family's communication patterns while inspiring them to think about new ways of communicating. These probes are not new technologies from a research perspective, but they are novel from the perspective of many families, many of whom may equate technology with desktop computers.

In the deployment of both probes, we ran into a number of technical and logistical roadblocks. We encountered service and administrative problems getting high-speed Internet access installed in some of the families' homes, as well as breakdowns of our own hardware and software, requiring additional visits to the families' homes to correct the problems. Despite these problems, we were able to successfully deploy the probes in families' homes for a month or longer. We offer these problems as cautions to other researchers, but believe they can be avoided or minimized in the future.

Figure 1. messageProbe

MESSAGE PROBE

The messageProbe is a simple application that enables members of a distributed family to communicate using digital Post-It notes in a zoomable space (Figure 1). It can function synchronously, with two or more family members writing and drawing from different locations at the same time, or asynchronously, with family members checking it periodically for new messages from other households. The probes are connected only to a small set of family members, removing the need for complicated setup and remembering names, addresses, or buddy lists. There is no mouse or keyboard – just a writable LCD tablet and pen.

Hardware and Software

The messageProbe software was built using Java and three Java-based toolkits: the University of Maryland's Jazz, Sun's Java Shared Data Toolkit 2.0 (JSDT), and Interbind's XIO, all available for download [1, 12, 14]. The hardware requirements include a writable LCD display, such as Wacom's PL 500 Series, or a regular graphics tablet and a monitor. The software runs on the Windows and Macintosh OS X platforms.

Design

The messageProbe builds on work from three fields. First, the technology is influenced by shared whiteboard projects for use in the workplace [21] and recent attempts to bring such technology into the home, such as the Casablanca project's ScanBoard [9]. Second, in an effort to keep remote family members connected, we were also influenced by research in remote awareness [3]. Finally, our interface design is based on zoomable user interfaces [1]. We also did a lot of work to make the visual presentation and interaction as minimal as possible so the application would feel more like the simple paper notes it was based on and less like a complicated computer with buttons and icons.

We decided to build the messageProbe based on virtual notes because of the popularity of paper sticky notes for informal family communication. We lost the ability to stick notes on anything anywhere in the house, but gained an unlimited supply of notes and the ability to share them remotely with other family members.

With the potential for multiple remote family members to be viewing, manipulating, and writing on their devices simultaneously, there were a number of usability and synchronization issues to consider. Not only do family members at multiple locations share the message space, but also multiple family members at the same location share a single message creation and viewing device.

Thus, we chose to implement a bulletin board-like interface. All users share control of the notes in the message space. Anyone can write on or move a note in the space, regardless of who created it. New notes are immediately sent to all the devices in the family and are displayed in the same location on all devices. We did not want to force an organization of notes on users, but needed some way of arranging them initially. Notes are arranged according to their creation time in a grid, with older notes pushed higher and made smaller.

Organization of notes beyond the default placement is up to users. Notes can be dragged out of the message grid anywhere in the message space. Notes can also be dragged back into the grid, where they resume their place in the time-based order. As notes are added or removed from the grid, the grid reorganizes itself to fill up space. This design allows for some interesting interactions, which add to users' sense of remote awareness. Two users can draw on the same note at the same time or one user can move a note that someone else is writing on.

There is no delete function – users add to existing notes, create new ones, and move old ones. Our first design included these features, plus time and date information for each message. However, we wanted the probe to feel different from a 'regular' computer, so we took away common visual computer signs, like title bars, borders, bad typography, symbols to click on, etc. After much design work and several iterations, there were no longer any complicated interactions or dialog boxes.

Users simply tap a virtual pad of notes to create a new one, and then write on it. Tapping on a note other than the one that currently has focus zooms the focus to the other note. Tapping outside a note zooms the space out to show all the notes. At the first demonstration of the messageProbe in Sweden to the Swedish families, three-year-old Vera simply started to draw on it, just as if it was paper and crayon. No instructions whatsoever were needed.

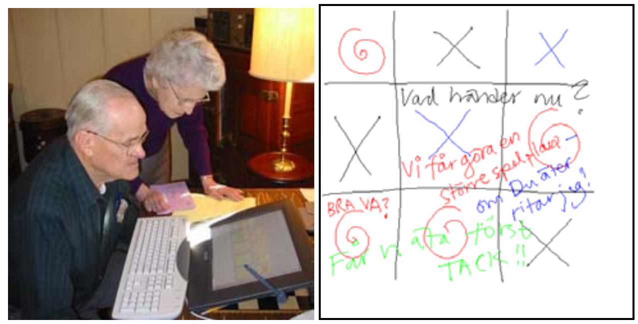

Figure 2. U.S. messageProbe (left) and Swedish message (right). (Note that the keyboard was not used for the messageProbe.)

Probe Deployment – U.S. Family

We deployed the probe in the three households of our U.S. family design partners for 6 weeks in early 2002 (Figure 2, left). These households included a nuclear family with two parents and two school-age children, and two sets of grandparents, all living within 15 km of each other. We provided computers and high-speed Internet access to both sets of grandparents; the nuclear family already had both. While we wanted to provide all of the households with a writable LCD tablet, we only had one of these devices. One set of grandparents used this device, while the other households used graphics tablets and monitors.

For all of the deployments, we wanted to be able to place the probes in high-traffic areas of the families' homes, where family members would hopefully look at them and use them often. We were relatively successful in doing this, but we had to respect the families' wishes and compromise in some cases. In the nuclear and maternal grandparent homes, the messageProbes were located in the kitchen and main living areas, respectively, both high-traffic areas. In the paternal grandparents home, the probe was placed in the basement, which was a bit more out of the way.

The family created over 120 messages during the trial, and in all of the households, someone checked the probe at least once a day. The messages were almost exclusively text, with few drawings or doodles. The two grandfathers wrote the most notes, followed by the father. The two children wrote a few notes each and the grandmothers and the mother wrote one or two each. The two sets of grandparents didn't communicate with each other directly - they each just wrote notes to the nuclear family, despite the fact that everyone could see all the notes. When we interviewed the families about this, we found that this lack of direct communication was typical. The grandparents got along, but did not need to communicate with one another often.

Status updates were the most numerous types of notes, but many of these had to do with technology problems. Notes about minor news, feelings, and coordination were nearly as numerous, while there were also a few questions and reminders. The only one who used the probe in the nuclear household regularly was the father. The children were frequently too busy, and the mother preferred the phone. The paternal grandparents had no prior computer experience, but the simple interface of the messageProbe provided a good introduction. The lack of a delete function made the grandfather self-conscious about mistakes, so he wrote many of his notes on paper first. The maternal grandparents had the most trouble with the probe. They required a new modem, a new IP address, and had a problem with their pen due to electrical interference.

Many of the family members wanted a notification function, such as an audio cue, for new messages. All the grandparents were disappointed that the grandkids didn't use it more, but the probe helped reveal that coordination between the nuclear household and the grandparents for childcare was an important issue. However, everyone felt that it was not reliable enough for important communications. It was fun, but the phone was better for a quick response.

Probe Deployment – Swedish Family

In Sweden, the messageProbe was installed in two households of one family over several months during the summer of 2002. We provided both households with LCD tablets and Apple Cubes. The households included two sisters, one living with her boyfriend and the other with her husband and two small children.

The first sister and her boyfriend lived in a small apartment and placed the probe in their bedroom, next to their computer. This was a high-traffic area, but they chose to switch the probe off at night because of the noise and light it generated. The second sister and her family placed the probe on an unused dining table in the downstairs of their house. The probe was visible from nearly every room downstairs because of the open floor plan in the house.

This family wrote over 200 notes during the course of the trial. There was considerable difference between how much the sisters used it vs. their husband and boyfriend. The sisters treated it as a natural continuity of how they already communicate - a constant flow of notes, with text and drawings, answering machine messages and telephone calls. Their use of the messageProbe was another way of leaving notes. By contrast, their husband and boyfriend did not communicate with either each other or their spouses to the same extent, and did not use the probe as often.

In contrast to the U.S. family, the Swedish messages were more playful (Figure 2, right). One sister played remote 'connect-the-dots' with her niece. The two children enjoyed the probe so much that at times they fought over the pen. For the adults, messages were often annotated repeatedly from both sides. When there was no more space to write, they continued on another note.

Like the U.S. family, the Swedish family discussed a visual or audio cue to provide awareness when someone on the 'other side' was writing a message. However, they also noted that there was a negative side to such a signal because it could be distracting or annoying if you were occupied with other things. They had similar technical problems with the probe not working at times during the trial, and the zooming feature on their computers was rather slow. In spite of the problems though, they all enjoyed it and said that it actually added a new dimension to their relationships.

Conclusions

Despite problems with robustness, the probes were helpful in revealing communication patterns and technology needs and desires. Many of the messages in the U.S. family involved attempts at coordination for things like picking up children, indicating that this is a promising area of research for new technologies. In addition, the playful use of the probe by the Swedish family indicated a desire for simple, fun ways of providing remote awareness between households. The probes also revealed more subtle aspects of communication in the families that would likely not have come up in interviews – i.e. the unique communication habits of the Swedish sisters and the U.S. grandparents.

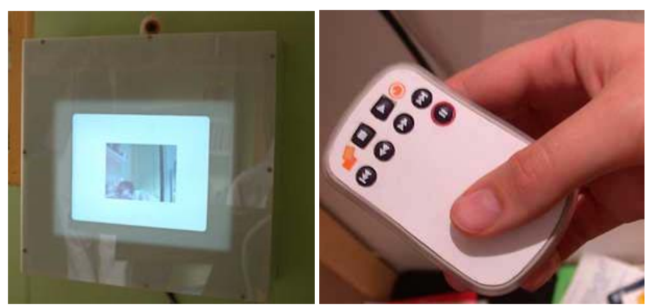

Figure 3. videoProbe (left) and customized remote control (right)

VIDEOPROBE

The videoProbe (Figure 3, left) provides a simple method of sharing impromptu images among family members living in different households. We use a video camera that takes a snapshot when the image it captures becomes steady for approximately three seconds. The images are stored and made available to anyone else in the network. Family members can browse the images with a remote control (Figure 3, right). Images fade over time and eventually disappear, to encourage families to create new ones.

Hardware and Software

The videoProbe consists of an Apple Cube, a Wacom PL-500 LCD tablet, a Philips ToUCam Pro USB camera, a pair of Apple USB speakers, a Keyspan Digital Media remote control, a USB hub and an Apple Airport base for wireless networking. We selected the Apple Cube both for its unconventional look and its silence (it has no cooling fan). Even so, some families complained about the hard drive being noisy. The screen/tablet is used only for display. The Airport base allowed us to install the videoProbe just about anywhere in the families' homes. The software is implemented in C++ with the videoSpace toolkit [23].

Design

The videoProbe was inspired by research on media spaces [2], which demonstrated the power of video to support remote awareness. We have chosen to share still images rather than live video for several reasons that relate to the goals of technology probes. First, real-time video would have been difficult to achieve in a home installation. Second, still images support asynchronous as well as almost synchronous communication [3]. Third, the design requires family members to interact with the probe, giving us a way to capture usage data and discuss their patterns of use.

Considering the variety of devices and cables involved in the videoProbe hardware, we had to develop a packaging design that was compact, non-intrusive and simple to handle. We structured the technology into two units: the computer and its power supply and a customised rectangular box that houses the screen and the rest of the equipment. These units are connected via a covered lead, which includes the video, power and USB cables.

The videoProbe was designed to be usable in a variety of spatial configurations within the families' homes. The box can stand alone on any item of furniture. A hole in the back allows it to be mounted onto a wall, like a picture frame. The unit may also lie flat on its back, so that it can be used for message/drawing applications.

We designed the display unit to exploit the high quality of the screen and video camera. At full resolution, the images do not fill the screen, so we covered the remaining parts of the screen and the rest of the box with white plastic. We wanted to keep the visual design as simple as possible, to blend in with any decor. The white plastic does not attract much attention and naturally disappears into its surroundings when the system is not active. When a family member approaches the videoProbe, the video fades in and highlights the packaging with a glowing white semi-transparent band, emphasizing the reactiveness of the unit.

The camera sits on top of the videoProbe screen, similar to a webcam on a monitor. We wanted family members to be able to point the camera in any direction, so we created a notch filled with foam on the top of the videoProbe. This makes it easy to lift up the camera, rotate it, and fix it into the desired position. The camera can be focused by hand and has a wide range, including objects that are only millimeters away. We provided a long cable, housed inside the box, to enable family members to take the camera out of the videoProbe to take close up shots of things nearby.

To simplify the use of the videoProbe, we created a custom-made graphic design for the remote control. Our earlier tests showed that even the few tasks executed by the remote control could be confusing. It was not obvious how to put an image into or remove it from the album, and these actions are not clearly related to culturally-established VCR control iconography, such as <<, >, >>. Note that users also face these problems when attempting to manipulate stored images on commercial digital cameras.

Figure 4. videoProbes in the French families' homes

Probe Deployment – French Families

We installed four videoProbes in the homes of two French families during the summer of 2002. The first pair of videoProbes was installed in the homes of two sisters, both living in Paris (Figure 4, left). The first sister designed a kind of 'media wall' for the probe in the corridor of her flat, due to the lack of space in the apartment.

The corridor was designed as a substitute for a social lounge area and the videoProbe fit very well into this environment. The second sister and her roommates let us drill a hole so we could place the videoProbe on the wall. They also moved things around and were interested in finding a location that was integrated into their living space. Unfortunately, she had to move soon after we connected the probe so we could only collect limited data.

The second pair of videoProbes was installed in the homes of two brothers, both living in suburbs of Paris about 20 km apart. These families decided that they wanted to place the videoProbes in the main living area, where they could be seen from both the sofa and the dining room table. Unlike the two sisters, their settings were more formal and we could not hang the probes on the wall. Instead, the families placed them on tables or sideboards, rearranged to accommodate plants, vases, and lamps (Figure 4, right).

Preliminary observations of the use of the videoProbes already show a variety of patterns of use. Kids and young adults like to use it in a playful way, e.g. sending pictures where they make faces or taking strange close-ups. They also use it for communication, e.g. taking a picture of a hand-written message. We expect these patterns to evolve when the probes are used over a longer period of time and become more integrated into the families' lives.

EMERGING DESIGNS

Our experiences deploying the messageProbe and the videoProbe in the homes of our family design partners has led us to two promising areas of research. Through log files, interviews, and workshops, the families have identified a variety of different interests, from practical to whimsical, for staying in touch with members between and within households. We are developing two types of prototypes that reflect this diversity: some to support family coordination and some to support playful interaction.

In addition, we have realized that families need a far better method of specifying with whom they communicate. To meet this need, we are exploring different approaches that will be integrated into our prototypes. Finally, our experience installing the probes to fit around existing objects in the home suggested that we should explore applications that take advantage of existing objects. We are designing some of our prototypes to address this need, by studying which objects in the home can be augmented to support coordination and playful interaction.

Family Coordination

One conclusion that we and our design partners drew from the technology probe installations was that coordination between and within households is important but difficult. Different family members have different coordination needs, and everyone makes use of different methods and tools. One workshop we held with the U.S. family following the messageProbe deployment was particularly useful in allowing them to reflect on this problem.

The goal of the workshop was to generate ideas for family communication and coordination technology, based on experiences with the probe. We motivated the discussion by discussing examples and events of coordination scenarios and breakdowns that we had learned about through the messageProbe trial. We split the family into teams and gave them low-tech prototyping art materials (colored paper, string, clay, etc.) to use to design technology solutions for the scenarios.

The mother and father wanted to keep track of everyone's schedules. They built shared calendars embedded in the refrigerator and added features to their cell phones to connect them with this calendar. Their use of the messageProbe was focused on coordinating their childrens' activities and getting help with this from the grandparents, and their prototypes reflected this need as well.

The grandparents wanted to keep track of people. They built key hooks by the door that noted who was home, and a ring that pinched the wearer if someone wanted to talk to them. Their use of the messageProbe was marred by technology breakdowns and by a preference for pen and paper over graphics tablets, and their devices reflected their desire for something simpler and more direct.

The kids designed small devices for keeping in touch with friends and parents – voice activated key chains for sending messages and watches that displayed after-school schedules. They didn't use the messageProbe much at all, saying that they were frequently too busy or not home. They wanted devices they could carry with them and use wherever they were.

Overall then, staying connected with and aware of family was important, but people had different motivations for doing so and wanted to do it in different ways. As a first step to supporting them, we are developing new coordination interfaces to enable households to view each other's schedules and to leave messages for one another. Later, we could extend this service to improve communication, portability, and tracking by supporting GPS-equipped PDAs, cell phones, and other small devices.

Family Playfulness

Another conclusion that became clear after the deployment of both the probes is that families want to have fun together, even at a distance. With the messageProbe, we saw tic-tac-toe boards, connect-the-dots games, and family member caricatures, all bringing family members from different households into shared, playful activities. With the videoProbe, early interactions included family members making funny faces at each other at a distance.

This is not a startling conclusion – Huizinga coined the term Homo Ludens in 1950, defining humans as playful creatures [10]. However, aside from games, the design of technologies has generally focused on tools to improve our efficiency, not to support our playful side. It is only recently that designers such as Gaver have begun to think about how to design to support playfulness [6]. Our technology probes were built to be open-ended and ambiguous to inspire new uses. The fun way our design partners interacted with them seems to validate the playful side. We are currently working on prototypes that build on these ideas.

CONCLUSIONS

We believe that technology probes are a promising new design tool for working with families as partners in the design of new technologies. Despite the technical difficulties encountered during the deployment of the messageProbe and videoProbe, we believe that as technology probes, they were successful in three ways.

First, they helped reveal practical needs and playful desires within and between distributed families. Second, they provided real-life use scenarios to motivate discussion in interviews and workshops. Finally, they introduced families to new types of technologies beyond the accustomed PC-monitor-mouse-keyboard setup, which we believe encouraged them to consider more whimsical and creative uses of technology in our design workshops.

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