Sharing Domestic Life through Long-Term Video Connections

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3

Video chat systems such as Skype, Google+ Hangouts, and FaceTime have been widely adopted by family members and friends to connect with one another over distance. We have conducted a corpus of studies that explore how various demographics make use of such video chat systems in which this usage moves beyond the paradigm of conversational support to one in which aspects of everyday life are shared over long periods of time, sometimes in an almost passive manner. We describe and reflect on studies of long-distance couples, teenagers, and major life events, along with design research focused on new video communication systems—the Family Window, Family Portals, and Perch—that explicitly support "always-on video" for awareness and communication. Overall, our findings show that people highly value long-term video connections and have appropriated them in a number of different ways. Designers of future video communication systems need to consider: ways of supporting the sharing of everyday life rather than just conversation, providing different design solutions for different locations and situations, providing appropriate audio control and feedback, and supporting expressions of intimacy over distance.

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1. INTRODUCTION

Over the last decade, we have seen a large uptake of video chat systems in the context of domestic life. By video chat systems, we are referring to synchronous video communication systems such as Skype, Google+ Hangouts, Apple's FaceTime, and other similar systems, which allow people to communicate and see one another from afar using both video and audio links. For example, grandparents use video chat to see their remote grandchildren [Ames et al. 2010; Raffle et al. 2010; Forghani and Neustaedter 2014], teenagers use video chat to hang out with friends [Kirk et al. 2010; Buhler et al.

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2012], and long-distance couples use video chat to stay connected with one another [Neustaedter and Greenberg 2012; Rintel 2013]. What has become particularly interesting to us as researchers is the manner in which such video chat systems are designed and the mismatch between that design and domestic use: that is, the predominant design paradigm is one of "video calling," in which a person selects a contact and places a call, much akin to the way people use telephones to call one another. Only now, video accompanies the audio link.

Over the past several years, along with our collaborators, we have conducted a corpus of studies that explore how various demographics and relationships use video chat systems as a part of their everyday domestic life. These studies have revealed that, despite most systems being designed to first and foremost support video calling, people have appropriated video chat systems in unique ways that allow them to *share everyday life* as opposed to simply calling one another for conversation. By this, we refer to the way in which video chat systems may be left on for long periods of time, with conversation not being the focus of interest. Instead, people monitor the other site and the people and activities within it, sometimes in a very passive way.

This general idea is not new. The topic of long-term video connections—sometimes referred to as "always-on" video—has a long history in the fields of Computer-Supported Cooperative Work (CSCW) and Human-Computer Interaction (HCI). In the 1980s and onwards, researchers explored the idea of media spaces: always-on video and/or audio links that connected coworkers who were within the same building, across buildings, or even across cities and countries [Mantei et al. 1991; Bly et al. 1993; Harrison 2009]. The goal was to use the systems to provide informal awareness of coworkers' activities such that one could easily move into casual interactions based on this awareness [Fish et al. 1990; Whittaker et al. 1994]. These interactions were shown to be critical for fostering collaboration [Whittaker et al. 1994] as well as building and maintaining social relationships at the workplace [Mantei et al. 1991; Dourish and Bly 1992; Jancke et al. 1996; Bellotti and Dourish 1997; Harrison et al. 1997]. Perhaps somewhat surprisingly, we are now seeing the emergence of open connections or always-on video in the home. While both settings focus on using video to support awareness, interactions, and the mediation of social relationships, the environments differ in terms of norms and expectations, as do the deeper motivations behind the use of the video connections. In the home, this tends to focus much more deeply on emotional attachment and closeness, as our article describes; in the workplace the focus is more centered around productivity and creating a pleasant work environment and culture.

This article focuses on exploring *open connections* in the *domestic realm.* We first examine and reflect on studies of three different situations in which video chat systems are being used to support long-term connections: by long-distance couples, by teenagers, and by mixed groups during major life events. For each study, we offer a critique of the design of existing commercial video chat systems (e.g., Skype, FaceTime, Google+ Hangouts) that are primarily used to support each situation. Second, we describe and reflect on the design and field trial usage of several domestic video communication systems—the Family Window, Family Portals, and Perch—that move away from the idea of video calling to one of always-on video for supporting the sharing of everyday life. For each study, we present its main findings, the implications for design, and reflections on those implications. With the exception of our study of Perch, these studies and projects have been previously reported piecemeal, providing valuable insights for designers of video communication systems. However, we feel that by presenting and reflecting on them as a whole, they provide a much larger lens through which one can begin to understand and analyze long-term video connections in the context of domestic life, where usage crosscuts demographics, relationships, and situations.

Overall, we illustrate the value in alternative design paradigms and features for synchronous video communication systems, identifying the benefit of always-on video

or long-term connections. Our hope is that this understanding helps researchers and designers move beyond the paradigm of video calling to one of *sharing everyday life*. At various points in the article, we also compare always-on video in the home to the historic accounts of always-on video in the workplace. This illustrates that while the core patterns of usage are similar in the two contexts, the nuances of when and how people make use of always-on video along with privacy concerns differ. The studies and analysis also reveal several lessons. These show that the always-on domestic video systems that have been created are perhaps overly simplistic when it comes to supporting the needs of people across varying domestic situations. Open-design challenges include providing different design solutions for different locations and situations, providing appropriate audio control and feedback mechanisms, and supporting expressions of intimacy over distance.

Section 2 describes related research on media spaces in the workplace as a backdrop for exploring always-on video in the home. In Section 3, we outline our own research studies of appropriations of video chat in domestic environments. In Section 4, we describe the design and evaluations of next-generation video communication designs. In Sections 3 and 4, we also present additional related research that helps to strengthen the understanding gained by our own work. In Section 5, we discuss the overall lessons we feel are pertinent to the design of synchronous video communication systems of the future.

2. MEDIA SPACES IN THE WORKPLACE

The idea of domestic media spaces primarily grew out of media spaces that were designed and studied in the workplace in the early days of the field of CSCW. Research shows that as coworkers become separated by distance, the likelihood of collaboration drops off because people find it challenging to informally interact with others or such interactions are not possible [Kraut et al. 1988]. Such casual interactions or informal encounters form a large portion of work activity [Whittaker et al. 1994]. Given this, researchers worked to find ways to connect distance-separated collaborators through technology to foster informal awareness of coworkers' whereabouts, availability, and activities such that coworkers could easily move into casual interactions [Bly et al. 1993; Fish et al. 1990; Bellotti and Sellen 1993]. There was also a need to support the building and maintenance of workplace relationships over distance [Mantei et al. 1991; Dourish and Bly 1992; Jancke et al. 1996; Bellotti and Dourish 1997; Harrison et al. 1997]. One design paradigm that became a dominant focal point of research was the media space: an always on video link (and sometimes audio) that connected two remote locations [Mantei et al. 1991; Harrison 2009].

First, several media spaces focused on connecting common areas like meeting rooms or kitchens [Bly et al. 1993; Harrison 2009]. This included the first media space at PARC [Bly et al. 1993; Harrison 2009], the Video Window [Fish et al. 1990], and the Virtual Kitchen at Microsoft Research [Jancke et al. 1996]. All were designed to support casual interactions and social relationships across distance-separated common spaces for people who may not normally see each other in person [Fish et al. 1990; Mantei et al. 1991]. Thus, conversations over media spaces were sometimes serious and sometimes more lightweight and "whimsical" [Dourish and Bly 1992], and occasionally about nonwork topics [Harrison et al. 1997]. Media spaces used a variety of configurations including small and large displays (some projected). Installations were comprised of dedicated devices and hardware that displayed only the video link (in contrast to a workstation that would be used for various purposes). Second, many media spaces were designed to provide connections between workplace offices or cubicles [Coutaz et al. 1998; Mantei et al. 1991; Dourish 1993; Dourish et al. 1996; Greenberg and Rounding 2001; McEwan and Greenberg 2005]. For example, CAVECAT connected

multiple coworkers' offices with always-on video, mostly of each person working at his or her desk [Mantei et al. 1991]. The designers' usage showed the importance of seeing oneself to adjust how one was presented remotely, the ability to detect eye gaze towards a colleague's video, and the ability to look at one's own office when at a colleague's (through the video link) [Mantei et al. 1991]. In another instance, the Notification Collage allowed coworkers to post video snapshots captured at their desks, sticky notes with typed messages, and other media items to a shared bulletin board [Greenberg and Rounding 2001]. The open and close-knit culture of the community of coworkers using it was pivotal to its success [Greenberg and Rounding 2001].

Regardless of the specific media space instantiation for office connections, privacy was nearly always a discussion point. One notable theory of privacy in video media spaces, articulated by Boyle et al. [2009], explored three interrelated privacy components as a part of media space design and usage: solitude, confidentiality, and autonomy. *Solitude* involves having control over one's interactions and, in particular, being able to choose when to interact [Boyle et al. 2009]. In media space usage, coworkers could work to mitigate solitude intrusions by attempting to determine one's availability through the video link prior to moving into interactions. Yet solitude violations still occurred from time to time [Dourish 1993]. *Confidentiality* focuses on control over what others know about oneself [Boyle et al. 2009]. This relates to challenges about how one looks on camera, how one's environment appears, and if sensitive information may be visible. For example, at times, certain individuals do not always feel comfortable being captured on camera because they are concerned about their own appearance [Neustaedter and Greenberg 2003; Boyle et al. 2009]. *Autonomy* involves control over how one interacts in a space and the ability to choose such interaction [Boyle et al. 2009]. For example, many media spaces reported situations in which visitors may enter one's office. Such individuals may be accidentally caught on camera despite their desire to not be publicized [Dourish et al. 1996; Boyle et al. 2009]. Cameras were also often purposely situated to capture large regions of office spaces to provide a broader context [Dourish et al. 1996]. Some were even aimed at capturing doorways or common areas such as hallways [Dourish 1993]. This caused additional privacy concerns around autonomy [Dourish 1993; Boyle et al. 2009]. Media spaces that were in common areas frequented by large numbers of individuals also raised issues with autonomy in which some people may not be aware of being captured on camera [Boyle et al. 2009; Bellotti and Dourish 1997]. Audio was also an issue with some media spaces as microphones could easily capture audio at distances that were even further away from the media space setup [Dourish et al. 1996; Belotti and Dourish 1997]. For example, in the evaluation of Thunderwire, an audio-only media space, coworkers reported privacy concerns related to overhearing a manager's conversation with coworkers, along with other privacy-sensitive discussions [Hindus et al. 1996].

Researchers have also described privacy in media spaces in relation to *control* and *feedback* mechanisms [Bellotti and Sellen 1993; Bellotti 1996]. Bellotti and Sellen [1993] define control as "empowering people to stipulate what information they project and who can get hold of it." This relates heavily to autonomy but also encompasses issues of confidentiality. Feedback is defined as "informing people when and what information about them is being captured and to whom the information is being made available." Again, this relates to both autonomy and confidentiality, where we see a desire to know about the recipients of information shared over a media space. Adequate feedback can allow people to appropriate themselves correctly—make oneself visually acceptable to be seen—for a given situation of being captured and broadcast over a media space [Bellotti 1998]. Research has also explored media space design and usage from societal and cultural perspectives [Dourish et al. 1996]. For example, it was clear that media spaces were understood differently depending on who was using them (or

not) and how familiar they were with the technology [Dourish et al. 1996; Bellotti and Dourish 1997]. Behaviors, practices, and understandings of media spaces also evolved over time through usage and observations of others [Dourish et al. 1996; Bellotti and Dourish 1997].

Next, we build on this knowledge to explore the ways in which video chat systems have been appropriated in domestic life as a form of always-on video through open video connections.

3. APPROPRIATIONS OF VIDEO IN DOMESTIC LIFE: FROM FOCUSED CONVERSATION TO OPEN CONNECTIONS

The first incarnation of video chat for domestic life occurred in the late 1960s and early 1970s when AT&T originally developed and marketed a "Picturephone": a small standalone device ($5^1/_2 \times 5$ inches) that transmitted audio and monochrome video to a second device over telephone lines [Noll 1992; Lipartito 2003]. Picturephone booths were set up in several cities within the United States; people were able to try them at a cost of between $16 and $26 per minute [Lipartito 2003]. The public reacted generally negatively towards the technology (and perhaps its marketing), and AT&T pulled the Picturephone. The Picturephone's failure was blamed on the privacy concerns of consumers, cost, market timing, and an inherent lack of need for video communication [Noll 1992; Lipartito 2003].

Yet times have changed—we now see families adopting and using video chat technologies to communicate with family and friends quite readily, despite technical and social challenges [Ames et al. 2010; Judge and Neustaedter 2010; Kirk et al. 2010; Rintel 2013; Forghani and Neustaedter 2014]. This is likely partly due to the availability of free video chat software like Microsoft's Skype, Apple's FaceTime, and Google+ Hangouts on computers, tablets, and mobile phones. Families also see clear benefits in being able to move away from audio-only phone calls to the combination of video and audio for communication [Ames et al. 2010; Judge and Neustaedter 2010; Kirk et al. 2010]. At work, video communication is often *imposed* on individuals when project teams include remote workers [Brubaker et al. 2012]. Yet, in the home, people *choose* to use video because they genuinely want to use it [Brubaker et al. 2012]. Research has shown that people feel more present with their remote loved ones over a video link because they can actually see them along with their body language and other visual cues [Judge and Neustaedter 2010; Brubaker et al. 2012; Neustaedter and Greenberg 2012]. People also value being able to give virtual tours to one another of remote locations and show various objects of conversational relevance [Kirk et al. 2010]. Grandparents and grandchildren enjoy reading stories together over video chat [Raffle et al. 2010; Forghani and Neustaedter 2014].

Within the context of the domestic life, studies have shown that two dominant paradigms of video chat usage exist. These range from *focused conversations* to *long-term, open connections* [Kirk et al. 2010; Judge and Neustaedter 2010]. While these paradigms comprise endpoints in a spectrum of uses that mix aspects of each, it is reasonable to consider them as distinct use cases. In the first case, people are directly talking to one another and largely stationary in front of the video display, akin to a video phone call. In the second case, *open connections*, people leave video calls open for several hours at a time, with less pressure to converse [Kirk et al. 2010; Judge and Neustaedter 2010]. Like always-on video in the workplace, the open video link supports awareness gathering, casual interactions, and the sharing of everyday happenings. Yet awareness of domestic happenings has additional importance for providing feelings of closeness between individuals at a much deeper emotional level than the workplace. Judge and Neustaedter [2010] show that such long-term connections were especially valued by families with children because they allowed them to *share everyday life* with

remote family members. Remote family members could see the growth of the children, their activities, and the somewhat everyday things they did. While seemingly mundane, it was very valuable to the remote individuals because it meant they were more a part of their family's life. Brubaker et al. [2012] also found that people often move beyond conversations during video calls to engage in *shared experiences* together, such as attending parties, television watching, date nights, and even helping fix one's car. While they do not label these as long-term connections, one could conceivably imagine many to be just that.

There is a danger in considering all domestic video connections as the same, as the actors involved and the context of use can differ considerably. In the following sections, we focus on three specific studies that explore how open connections are used in three different situations: remote living by long-distance couples, hanging out by teenagers, and sharing major life events with family members and close friends. These studies were selected because one or more of the authors of this article conducted them; this means we have deeper insight to the nuances of the research. Perhaps more important, however, each study presents a unique situation in which long-term connections are used for goals that varied considerably. These studies provide a backdrop for critiquing several systems designed specifically for always-on video, detailed in Section 4.

3.1. Long Distance Couples

The first study we discuss focuses on long-distance couples: partners who live in two different residences that are separated by distance. Full details of this study are found in Neustaedter and Greenberg [2012]; vignettes representing actual video usage are found in Greenberg and Neustaedter [2012]. This study included 14 participants (7 female) who were in serious long-distance relationships. The distance between partners varied widely. Some lived within a drive of an hour or two, others were separated by a flight of several hours, and some were separated across the world. Participants were between 19 and 35 years of age. Semistructured interviews were conducted with each participant individually. Nearly all participants used a laptop to connect with their partners.

Shared Living. Long-distance partners highly valued video chat because it allowed them to simulate shared living over distance. That is, video chat usage was dominated by leaving a video link open for an extended period of time, usually at least several hours. This predominantly occurred during weekday evenings when both partners would return home from work. Thus, it was routine and habitual, much like when a co-located couple expect to see each other when they arrive home from work. Partners called each other over video chat, then would leave the video link going throughout their evening. While it was running, they would do what they normally did around the house, only the remote partners now had the ability to see and hear each other doing these activities. This might involve cooking, eating dinner, watching television, or cleaning. Sometimes partners would be doing different activities than one another and occasionally would glance at the video link or say something. Other times, they would be doing the same activity together, such as eating dinner together or watching the same television show.

> "We use video as a method to ***simulate shared living***. Even if we aren't talking, the video channel is open. In fact, even when open it is on mute most of the time… We do the things we would normally do if we were together and can see one another doing it." – Participant 10

Multiple Locations. Regardless of the activity, many couples found great value in being able to easily move their video link around with them as they moved between locations in the home. For example, if they decided to cook dinner they would move

their laptop (running Skype) to the kitchen. When in the living room, they would move it to a coffee table. This was mostly done so they could actually see each other as they went about their daily in-home activities. Some even moved their laptop into the bathroom when getting ready for bed in the evening or when getting ready for the day in the morning. Others would move their laptops to the bedroom where they would fall asleep together with the video link running. Thus, mobility was highly important, but it also presented a challenge. Many participants had older laptops that were hard to move or had batteries that died quickly. Some locations were also not conducive to electronics because of limited counter space or poor lighting. For example, a kitchen or bathroom counter near a sink was particularly dangerous for laptops, while beds with sheets made laptops overheat. Such locations also typically had poor lighting from lamps or were used during the late evening when lights were turned off. We also recognize that moving a laptop around the home also impedes one's ability to naturally perform activities. Rather than having the technology blend in to the background, it easily becomes the focal point of the activity, as users must ensure that the right location is being captured and update camera placement as one's location or activity changes. Thus, users are nearly always cognizant of what is being captured and not solely focused on their own activity. Some choose to not move their devices because of this complexity.

Current commercial video chat systems (e.g., Skype, Google+ Hangouts) and the computers that they run on are limited in terms of the accessibility of cameras and their ability to capture a variety of locations around the home. Current systems allow users to utilize multiple video streams in a single video call; long-distance couples could use such a setup to show various locations in the home. Yet nobody in our study did this, and we feel it would be cumbersome at best. Multiple user accounts would be needed (one per device) along with multiple devices that offer both a camera and display. For example, long-distance partners could place a suite of tablets in different locations of their homes and use a different video chat account on each device. This creates a hardware challenge, however. People simply do not have that many devices to dedicate to such usage (and it is too costly for most to do so). It also reveals a larger problem in terms of the design of video chat systems. Present- day systems assume that each camera's view is focused on an individual, rather than a location. That is, they are designed to support conversation. In this context, it would mean having each device's view shown at the same time in a grid-like fashion (as with security cameras), or alternating in prominence based on motion or audio detection. Instead, long-distance partners would be better served by solely showing the location in which a partner is located, rather than all areas captured by cameras.

Physical Intimacy. We also found that some couples would attempt to engage in physically intimate acts while their video connection was left open. In the most basic case, this involved virtual hugging and kissing where partners would perform gestures in front of the camera, e.g., blowing a kiss, moving one's arms in the shape of a hug. In more extreme situations, this involved engaging in cybersex (or trying to), with partners in the nude or partially nude, watching each other pleasure themselves. Yet, again, the technology made this challenging as partners wanted to actually physically touch each other. Instead, such acts were often felt to be "awkward" or less than satisfying. Thus, there are obvious limitations related to physical intimacy. Existing commercial video chat systems focus on translating physical acts into video streams displaying such acts, for example, the physical act of kissing becomes a visual representation of it. Again, this is because the expected use of commercial video chat systems is one of talking and gesturing, in which seeing such acts is enough to support conversations. There is also typically a mismatch in alignment between the camera and display. Simple acts such

as blowing kisses become a complicated endeavor in which a person must look at the camera to align one's gesture, rather than looking at one's partner on the video display.

Providing support for physical touch is obviously very difficult and an open design problem. One approach is to augment video connections with human-like body parts that could be remotely controlled, for example, an arm and hand [Nakanishi et al. 2014]. Such approaches could easily be uncanny at best and, again, may force users to think less about the activity at hand and focus explicitly on manipulating such physical contraptions. Alternative approaches—such as remotely controlled teledildonics—have emerged, with careful attention being paid to the aesthetic design of such devices and the associated experiences [Bardzell and Bardzell 2011]. Here partners may have more natural control over how physical objects affect their partners, but, again, it is only a substitute for physical touch.

Yet it could be a mistake to overemphasize physicality. When our participants spoke of physical acts, they all described it as a way to share emotional intimacy: that is, physical expression was mostly considered a means to express mutual closeness. Thus a broader consideration that may show promise is focusing on how people can express emotional intimacy, affection, and feelings of closeness. One possibility could be to design the media space to emphasize the atmosphere and ambiance of the situation rather than the act of touch itself. For example, there is a certain level of romanticism that typically goes along with physical acts of intimacy. Rather than video chat systems being designed for devices like laptops, tablets, and smartphones that we commonly see throughout our day (and that are hardly symbols of romance), video chat systems could run on hardware that is more carefully crafted for the specific purposes of fitting into an intimate atmosphere. For example, albeit "cheesy" to some, one might imagine video systems embedded in romantic objects such as candles or stuffed hearts, or hardware specifically crafted to fit more "romantic locations" such as a bubble bath or bedroom, or that includes lighting more conducive to two lovers.

Privacy. Privacy issues came up in a number of situations for our participants. First, their usage of video chat primarily during weekday evenings reflected the autonomy that both partners wanted to maintain—weekends were for being out and about (without one's partner) while weekday evenings were for being together at home. They also desired solitude from other friends or family such that they could spend more time with their partner at home. Yet this is at odds with most video chat systems, which would display them as "available" for conversation to others because they were using the computer running the chat system. Thus partners had to defeat the availability display features, usually by manually configuring the system to show themselves as unavailable or offline after they connected to one another. When it came to physical intimacy over video chat, somewhat surprisingly, only a few people reported concerns about confidentiality breech, in which others (e.g., hackers) might see them doing such acts. A small number of people were also concerned about how they would appear over video when partially or completely naked.

3.2. Teenagers and Video Chat

The second study we focus on looks at the use of video chat by teenagers; full details can be found in Buhler et al. [2012]. This study included 20 teenagers (10 female): where four were between the ages of 13 and 15, and 16 were between the ages of 16 and 18. Fifteen participants used video chat weekly and five used it infrequently, once every 2 to 3 months. Again, participants were interviewed individually about their uses of video chat.

Hanging Out. Video chat primarily provided teenagers with a convenient means to hangout with their friends at a broad range of times. Thus, teenagers routinely

connected with people who lived very close to them (e.g., within the same general neighborhood), their friends from school or other extracurricular activities. This was often because they could not drive to meet with them (they did not have a driver's license or car) or they were restricted to being home at certain times. When connected, teenagers did a range of activities over video chat. Like other demographics, the video chat connection was often left open for hours at a time to make it easy to share activities longer term. This included showing new items, doing homework together, performing for one another (e.g., skateboard tricks, musical instrument playing), playing games, and gossiping. To a lesser extent, teenagers would sometimes flirt and engage in "showing skin." Across these activities, teenagers used a mixture of laptops and smartphones to video chat.

> [With Skype] You have the visual aid, you can show them what you've done rather than just try to explain it... It's the convenience factor, being able to do it from home. Let's say I'm at home, it's, like, after dinner, usually parents are just, like, 'Okay we're really not going to be leaving the house at like seven or eight o'clock' but you do have, like, this difficult [homework assignment]. It's just again the convenience factor—you don't have to leave the house, you can just be, like, 'Okay, let's go on Skype, we'll figure this out' rather than you have to drive fifteen to thirty minutes, like, wherever you may live in town to come help me with this problem.—Participant 16

Together, these findings illustrate that video chat was not first and foremost about feeling close to someone since the teenagers routinely saw their friends in person at school. This is different from adults, for whom feelings of closeness are indeed the main motivator to use video chat. The adults in our other studies also generally connected with people who lived far away. The focus on "hanging out" also meant that teenagers had little patience for bad connections or video lag. Such issues are commonly reported for video chat usage [Ames et al. 2010; Kirk et al. 2010]. In contrast, adults often value a video link so strongly that they will "put up" with a bad connection simply so that they can see their distant loved ones [Brubaker et al. 2012].

Locations in the Home. Teenagers are currently limited by the devices that they use for video chat, namely, a laptop or smartphone, and their ability to support a longer-term connection. Long-distance couples typically moved throughout their house while their video connection was open. Teenagers did not. Instead, they were often in the private confines of their bedroom. This means that a single camera/display may be adequate for teenagers, in contrast to long-distance couples. Yet in the context of the bedroom, we see existing commercial video chat systems posing similar challenges for teenagers as they do for long-distance couples. It may be hard to place laptops in ideal locations in the room (e.g., on a bed or small desk/stand) and lighting conditions may be poor. Commercial video chat systems and the corresponding hardware on which they run are designed as a "one-size-fits-all" solution to locations: that is, they are not custom designed for different rooms with different environmental attributes.

Locations Outside of the Home. In contrast to long-distance couples, for whom video chat usage was predominantly *within* the home, teenagers also used video chat *outside* of the home, for example, in their driveway or yard. This allowed them to share performance acts, such as skateboarding or biking, or set up an open connection in a yard to simply hang out. Participants talked about having to carefully position a phone to get the right camera angle or hold it somewhat awkwardly in front of them with one arm. Similar issues were reported by people using smartphones for video calls in public settings such as on public transportation [O'Hara et al. 2009]. While commercial video chat systems such as Skype or Google+ Hangouts have software designed specifically for mobile devices, there is little consideration as to the design of the hardware being used for such systems. The assumption is, again, that users will hold the mobile device

and focus on their face while they converse. Instead, teenagers need better mechanisms to easily support the placement of devices outdoors so that they do not need to be held and can be placed in a way that allows teenagers to capture a larger area of space.

Companies are now designing wearable video streaming devices such as Google Glass, Looxcie, or GoPro cameras for sharing outdoor activities with remote people. However, the emphasis with these technologies is on sharing first-person views. In the case of skateboarding (and other similar acts), teenagers would not be able to present and share how *they* look when they are performing for others. This suggests different hardware paradigms for mobile video chat that support the placement of cameras and video displays in the outdoor environment to capture such third-person views. For example, devices such as the Experiences2Go prototype [Inkpen et al. 2012] (comprised of a networked tablet and a camcorder with telephoto lens on a tripod) might suffice if they were easy for teenagers to move around, and possibly even take with them (e.g., when traveling to another friend's house). Again, this presents an open-design problem with multiple possible solutions.

Privacy. The video chat routines of teenagers reflected the high value that they placed on privacy and choosing when and how they participated in open video connections. Video calls often occurred in participants' bedrooms so that they would be able to socialize with their friends in a private area away from the watchful eyes of their parents. Thus, teenagers exercised their autonomy by choosing where to video chat. They were also quite particular about ensuring they looked "good" when viewed on camera. This reflects concerns over confidentiality and highlights teenagers' desire to adequately appropriate themselves for video calls. Other studies have shown that some adults are self-conscious about their own appearance over video chat, though many overcame this concern in a short period of time [Filho et al. 2009; Brubaker et al. 2012] (with an exception being situations involving poor health or chronic illness [Pang et al. 2013]).

Within the confines of their bedroom, teenagers were also careful about what was visible over the video link. This reflects their desire to maintain autonomy (or control) over how the call takes place [Boyle et al. 2009]. Unlike long-distance partners, a narrow field of view was often more desirable by teenagers. This provided them with a simple mechanism to hide certain parts of their room (e.g., messy areas). However, it also created increased privacy risk because people could be outside of the camera's view and not captured by it, but still able to see the video display of the remote person, for example, friends who are close by, or even parents who might come into the room. A similar finding was found for adults using mobile video chat while on public transportation [O'Hara et al. 2009]. This raises issues in relation to control over how teenagers are presented and seen in video chat systems, as well as adequate feedback of such disembodied individuals (e.g., parents, other friends off camera) [Bellotti and Sellen 1993; Bellotti 1998]. In comparison, long-distance partners are not typically concerned about restricting the viewpoint of their space. Thus, we can see that privacy issues present unique challenges for teenagers when compared to long-distance couples.

3.3. Major Life Events

The third study of video chat focuses on the use of video chat during major life events; full details can be found in Massimi and Neustaedter [2014]. This study involved the completion of a mostly qualitative online survey by 84 participants (56% female). Participants were predominantly from the United States, with smaller numbers from Canada, India, and Mexico. Most participants (72%) used Skype while others used Google+ Hangouts, FaceTime, ooVoo, and Line. Participants reported using video chat to support the sharing of a range of major life events. In this section, we focus on

activities that spanned a longer time period, in which a video connection was left open to allow remote viewers to witness the event, rather than explicitly partake in conversation. This includes activities such as weddings, baptisms, funerals, graduations, and birthday or anniversary parties.

Special Moments in Life. Sharing major life events over video chat was about allowing people who lived far away to be a part of a special moment in a loved one's life. Participants described these moments and events as difficult to forget, cherished over time, and sources of periodic reflection. These events also had a very large emotional impact on people and were situations that they had a strong desire to share with family or close friends. In these situations, people naturally wanted to attend the event in person because of its significance, but they were limited due to an inability to travel easily. Unlike connections between long-distance couples and by teenagers that occurred daily or every few days, streaming a major life event was a much rarer activity, occurring once every few months, yearly, or sometimes even less frequently.

> It was my grandpa's 90's birthday this past summer. I wasn't able to fly in to join the festivities, so I convinced my tech-savvy brother to set up the webcam and stream the party. It was a surprise, so I got to see the moment he arrived at the party. I got to see him being presented with gifts, which included a live band for the evening. It was great. Truly the next best thing to being there.—Participant 18

> It was my sister's child's baptism or naming ceremony. My brother who works in UAE was unable to attend the function. So we had him live over Skype and he was able to view the whole function over the Internet. The event mainly comprises of the baby's father whispering the name in the baby's ear. Then all the relatives feed the baby with a drop of milk. After this, the baby is gifted gold jewelry. Then the lunch would be served.—Participant 23

> My son had a "promotion" ceremony, which was like a graduation from middle school to high school. The school has wifi, so I brought my Chromebook with me so my mom could "be" at his promotion ceremony. I made sure to get to the school early so that I could get a seat in the front row of the bleachers. She turned her camera off, so she could see what was happening but wasn't visible on the screen. When my son's name was called, though, she turned her camera on so he could see her face when he walked past our section of the bleachers. She was able to see and hear the whole event.—Participant 47

Normally, a single person was responsible for setting up and maintaining a video connection during the sharing of major life events. In nearly every case, this person did not have any special training or professional experience in capturing a life event (as opposed to a professional videographer or photographer). Instead, it was somebody who was already attending the event locally, such as a family member or friend. This had the added effect that this person often had to focus on streaming the event to one or more remote family members at the expense of paying full attention to the event. Those managing the video stream would often hold up smartphones or tablets to capture the event, despite challenges in doing so for long periods of time (also found in our study of teenagers). Others set laptops on tables or chairs to stream the event. Rather than interact with a large number of people at the event, remote viewers were restricted to simply viewing the event and, sometimes, interacting with a smaller group. Interactions with larger groups of people were cumbersome because they relied on continuous support from the local "handler" of the video streaming device.

Locations. Video streams often focused on the front of large rooms, for example, graduation stages, the bridal party in the wedding, a casket and podium at a funeral. However, respondents wanted to be able to see different camera views and angles and move throughout the environment, which is not possible with existing commercial video chat systems. All are tied to a single camera within the device being used. Even simple features such as camera zooming are not possible with commercial video chat

systems. Like long-distance couples, one possible solution involves multiple cameras within the environment being captured. For example, in a wedding hall, this might mean a contextual view from the back of the room, an up-close view of the bride and groom, and a panoramic view of the bridal party and the official conducting the ceremony. Like situations in which teenagers are streaming performance acts, it may also be advantageous to not have a handler holding the video device with the camera. For example, remote viewers could easily handle the act of selecting camera views on their own, though this might limit their ability to interact with others in the setting since they would not have any embodiment. Presently, this embodiment comes in the form of the video handler holding a smartphone or tablet, or having a laptop placed in a visible location. Again, this presents an open-design problem.

Atmosphere and Ambiance. Major life events often have a particular ambiance and atmosphere to them, that is, the environment and its setup are often special in some way. For example, at a birthday party or wedding there are decorations and people often dress up. At a funeral, people again dress up, but it is a very somber atmosphere and environment. Respondents reported on large mismatches in the environment that was being captured and streamed over video chat compared to the location in which the event was being viewed. Those watching at home typically did not dress up to match the dress code of the remote event, and they certainly did not decorate their home similarly.

Thus, like the ambiance and atmosphere desired by long-distance couples in the bedroom, we see a similar need for broadcasting or sharing environmental attributes of the location in which the major life event is held. Without this, remote attendees may easily feel they are not really at the event. One could certainly think about designing to support a sense of atmosphere in which the remote location may look and feel similar to, for example, the wedding hall. However, we caution against such approaches as this could easily detract from what makes a major life event so major, or special: that is, the mere notion that the event cannot be recreated is often what makes it special. One possible solution is to have designers consider ways of accentuating or showing the special circumstances of the event in its true setting, rather than replicating it remotely. For instance, it may be valuable to see areas at the remote wedding that contain more than just the people. Additional cameras might broadcast the view outside of a church, the entryway to the main hall, or panoramic views of the crowd that has gathered to view the event. In this way, the atmosphere of the event may be even more understood by the remote viewers than would normally be seen through a single narrow-field-of-view camera.

Privacy. Privacy concerns related to confidentiality and the capturing of other attendees at the events were mostly nonexistent. Respondents felt that attendees would not mind if they were streamed as part of the video call since cameras and video cameras were already prevalent at most of the events anyway (perhaps with funerals being the exception). In the case of video chat, content was also just being streamed and not recorded. This was deemed to be less intrusive.

4. DESIGNS OF DOMESTIC MEDIA SPACES

The three studies that we have presented illustrate the different ways in which conventional video chat systems were appropriated to support long-term, open connections in the context of domestic life. We now move to the presentation of design work on video communication systems designed specifically to support such long-term video connections and so-called always-on video. We begin by describing related design research focusing on: activities *within the home,* activities *outside of the home,* and *mixed-context situations* involving telecommuters working from the home.

First, systems have been designed to support long-term connections *within* the home. For example, VideoProbe transmitted video snapshots between two remote families' displays when motion stopped in front of the display [Conversy et al. 2003; Hutchinson et al. 2003]. Participants found great value in being able to see a record of past snapshots that were recorded by the system [Conversy et al. 2003]. Yet privacy challenges emerged when participants would turn the camera off on occasion (because they did not want to be seen) and then forget to turn it back on [Conversy et al. 2003]. The Share Table allowed children of divorced families to play with their remote parents, discuss their activities, and even do homework together [Yarosh et al. 2009, 2013]. Study results showed that the system allowed parents and children to feel closer to one another over distance. The Family Room connected grandchildren and grandparents over distance through the use of multiple handheld or large wall displays and multiple cameras [Oduor and Neustaedter 2014]. The goal was to support the viewing of grandchildren from different perspectives and to alleviate children's frustrations with having only a single video chat device per call. Later in this section, we describe two similar systems in detail, the Family Window [Judge et al. 2010; Neustaedter 2013] and Family Portals [Judge et al. 2011] designed by a subset of this article's authors along with various collaborators.

Second, we have also seen video chat systems designed to support the sharing of domestic life *outside* of the home. For example, Peek-A-Boo allowed users to share live video between a mobile phone and in-home video display with a camera that was always-on [Neustaedter and Judge 2010]. This could be used to share family activities occurring outdoors with those at home, for example, soccer practices and ballet recitals. It could also be used to look in on the home to see who is around and what is happening. Experiences2Go also provided a mobile user with a means to broadcast activities while outside of the home to remote family members at their home [Inkpen et al. 2012]. A field study revealed the importance of supporting conversation while broadcasting video and the ease of being able to set up and hold the camera. Procyk et al. [2014] studied mobile video streaming (similar to Google Glass) for shared geocaching. The goal was to understand how remote family members could participate in outdoor activities together such as hiking or site seeing. Results showed that video and audio connections created a "micro-shared experience" with remote partners during which they often became disassociated with the activities and people around them and were overly focused on their remote partner.

Third, there are also a small number of media spaces that bridge home and work contexts. For example, the Home Media Space connected telecommuters to office-based colleagues [Neustaedter and Greenberg 2003]. Sensors were used to detect the presence of the telecommuter working in the home office as well as other family members who may have entered the room. Based on a set of rules, video would be transmitted or automatically turned off. Second, the MEdia Space (capitalization intentional) connected a telecommuting professor with his research lab at a university [Voida et al. 2008]. Students and other researchers could go in to his physical office on the university campus to see a video of him working at home and interact with him over the video link. This research revealed the importance of "asymmetry" in media space design. This idea explicitly recognizes the different benefits, costs, levels of engagement, and types of participation that people on either side may have for a video link. Voida et al. [2008] argue that rather than design to remove such asymmetries, system designers should think about embracing and designing for them.

In the next section, we look more deeply at three always-on video systems designed for usage *within* the home: the Family Window, Family Portals, and Perch. These systems were designed to generally support family connections in the home and not necessarily the situations presented in the previous three studies from Section 3. As

Fig. 1. The Family Window running on a tablet PC.

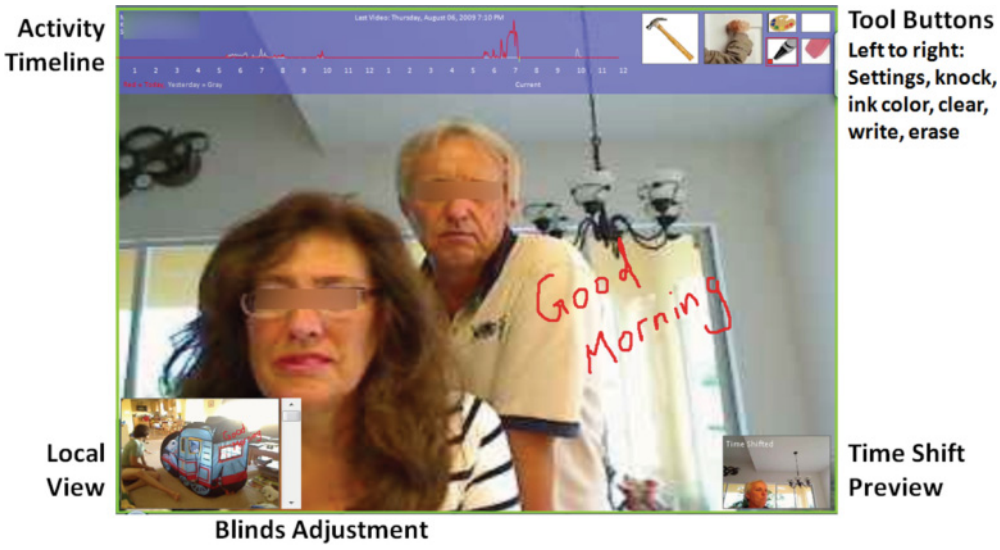

Fig. 2. The Family Window's user interface.

such, we describe how families used them for their intended purposes, then reflect on how the systems may or may not support the situations presented in the three studies.

4.1. The Family Window

The Family Window (Figures 1 and 2) was an always-on video system for the home—prototyped on a standalone tablet device—that transmitted video continuously to a remote home. The main view contained a video of the remote home (at ~2–3 frames per second[1]) and a feedback view of local video was shown in the bottom left corner. In Figure 2, the main view shows two grandparents and the local view shows their

[1]This was the fastest we were able to get video to transmit given that the system was still a prototype.

daughter and grandson playing with an inflatable toy train. Local video could be turned on and off by touching the local feedback video view. The prototype also contained an activity timeline on the top of the display to show movement at the remote location. If turned on, a time shifting feature recorded video throughout the day that contained movement. This video could be played back at any point that day but it was automatically deleted after 24 hours. A preview of recorded video was shown in the bottom right corner of the display. Users could draw or write on top of the remote video view to leave handwritten messages for one another. An audio link was not included because it was too technically challenging (at that time) to implement at a high quality. While this may seem to artificially limit the system, this decision also provided insight into the need for audio, as well as the fact that audio can be overly privacy intrusive (we return to this topic when we describe the evaluation of Perch). Full details of the design can be found in Judge et al. [2010] along with a video demonstration of the system in Neustaedter et al. [2010].

The Family Window was created using an autobiographical design approach [Neustaedter and Sengers 2012], documented in Neustaedter [2013] and Neustaedter et al. [2014], in which the Family Window linked Neustaedter's home to that of his parents (the grandparents of his children) for over a year. The Family Window's design was also evaluated with an additional two pairs of two households (four families in total) over a period of 4 weeks [Judge et al. 2012].

Awareness and Privacy. This evaluation, along with the autobiographical design usage, showed that the Family Window became a critical communication and awareness device for the families. Family members highly valued the ability to see the everyday mundane things that their loved ones did and felt much closer to them as a result. Sometimes they did not even need to see each other in the video window. Simply seeing the remote location and its contents helped make people feel as though they were "present" at the remote location. They also found that the Family Window provided them with a sense of availability awareness: that is, they could look at the Family Window and see if their remote family members were around or busy, and use this information to time phone calls to the house. Initially, family members were concerned that the Family Window was revealing too much information about the remote household and breeching confidentiality, but, within a few days these feelings disappeared. They did not report autonomy and solitude as an issue. We had designed "blinds" that could be adjusted to block or obscure portions of the video (Figure 2, bottom left), yet these were very rarely used beyond the initial few days of a family's usage when they first tested them out. Families recognized that they were connecting with people with whom they shared a close personal relationship and that the location of the Family Window, often in the living room or kitchen, showed fairly mundane activities.

Dedicated and Passive Device. We believe that a great deal of the success that was found with the Family Window was a result of its design as a dedicated device. People were not multitasking on the tablet or using other programs. The idea of the prototype was that it was *just* a Family Window and nothing else. This meant that family members easily understood what it was for and how they could use it, without a plethora of other functionality available as might be found on a device used more like a computer. Families were also given a device to use during our studies. This meant they did not have to use an existing smartphone or tablet that might be already used for other purposes. They were able to dedicate the tablet solely to the Family Window.

The Family Window was also a passive device that was always streaming video. This always-on nature meant there was little or no effort needed to see a remote family, one simply had to glance at the display. Our previous studies revealed that people appropriate existing video chat systems in a similar way, despite them being designed

with a calling and contact-list focus. With the Family Window, one could connect only with a single home; the suggested use by design was one of a long-term connection. Thus, the lack of a calling feature appears to be largely what supported awareness with the families who used the Family Window.

Reflections. Overall, the study results showed that the Family Window worked well in the two-home setup for which it was designed. But would it work well for the three design situations that we previously described—long-distance partners, teenagers, and major life events?

For long-distance partners, the answer seems to be a partial yes. Partners could place the Family Window in a location of the home that they wanted to connect, and it would support availability awareness and the viewing of everyday mundane activities at both locations. Yet it would not easily support mobility or capture from multiple locations within the home because the camera was embedded in a single device, as in commercial video chat systems. One might imagine placing multiple Family Window devices in different locations of the home. However, the Family Window's design would limit this setup to only connect pairs of rooms—it supported only two-way video. While seemingly cumbersome, one could use such a configuration to connect rooms of the same type, for example, living room to living room. At first glance, this may seem awkward, but it could create additional feelings of presence. After all, when physically living together, people have to be in the same room to see each other, much like this type of Family Window setup would produce. This solution, however, would still require the purchase of multiple expensive tablet devices. The lack of audio would also interfere with long-distance partners. While some partners reported that they sometimes kept the system on mute, it was fairly easy to turn audio back on. With the Family Window, the partners would have to communicate "out of band" over, say, a telephone. This extra step (and additional device) would likely interfere with their routines and feelings of intimacy.

When it comes to teenagers' routines, we feel that the Family Window may partially work but in a much more limited context. It is unlikely that teenagers would leave such a device always on. Instead, it might be used for several hours at a time while teenagers virtually hung out together. Teenagers would also not likely use such a system within the broader context of the home; it would be exclusively used by them among their friends and not include other family members with whom they lived. The lack of audio would also be problematic, as teens tend to chat over the video link. The limited frame rate could be an issue, especially during performances during which one teen wanted to show another teen an action. For both long-distance partners and teenagers, the Family Window would suffer from the same environmental issues as commercial video chat systems: lighting would be problem in bedrooms, as would the placement of the device in cumbersome locations, such as on one's bed.

Last, one could imagine embedding the Family Window in a venue such as a church or graduation theater to support the viewing of major life events; however, like commercial video chat systems, the view would not likely suffice since, again, it would be from a single camera in a fixed location and not able to present a broader sense of ambiance and atmosphere.

4.2. Family Portals

Family Portals was an always-on video system for the home, designed to explore shared connections between *three* homes. Figure 3 shows the design containing two targeted portals on the left—one for each remote family—and a shared portal on the right that supported leaving handwritten messages for both families. All families saw the video feeds from the other two families. Each targeted portal was essentially a Family

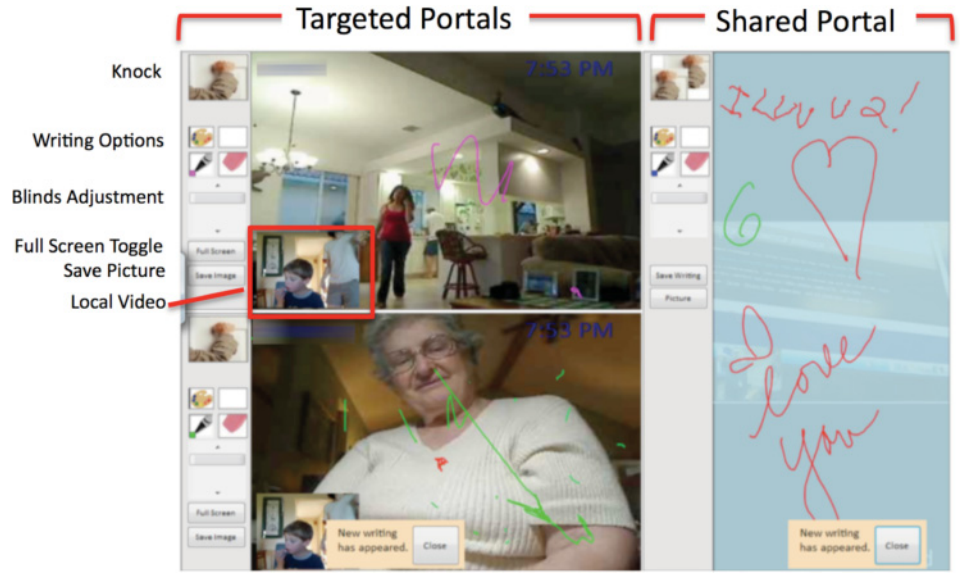

Fig. 3. The user interface for Family Portals. Image reprinted with the permission of the participants.

Window that contained a similar set of functionality. Full details of the design can be found in Judge et al. [2011]. To understand how families would use Family Portals, it was deployed to two different triads [Judge et al. 2011]. The first triad connected the home of a daughter and her family (Home 1) with her parents (Home 2) and her grandparents (Home 3). The second triad connected the homes of two sisters and their families (Homes 1 and 2) with their mother and her partner (Home 3).

Awareness and Privacy. Overall, the system showed similar benefits for the family members as the Family Window. They used Family Portals to gather an awareness of what others were up to; simply seeing remote family members and their home made one feel closer to them. The women in both triads especially loved seeing one another as well as each family's children. Because there were more individuals being connected across the three households, they were able to see more people; the amount of interactions that occurred through the system increased over that of the Family Window. More challenges also began to emerge, however. This occurred for individuals in each of the two triads. In the first triad, the grandfather in the family felt that Family Portals was focusing too much on one set of his grandchildren and great-grandchildren. In a sense, it provided too much information and too strong of a connection to them for his liking. This was especially the case because he had many other grandchildren and great-grandchildren for whom he did not use such a system. This individual was also less comfortable with technology in general.

In the second triad, neither of the male partners of the two sisters liked Family Portals because it was seen as being too privacy intrusive. In both situations, they had confidentiality concerns about their parents-in-law seeing them on Family Portals. As a result, they made sure that Family Portals was placed in a room of the home that they were not often occupying to exercise their autonomy. They also would sometimes turn the camera to face the wall, or turn off the system altogether.

Reflections. Thus, we can see that as the number of people involved in a video connection increases, so does the diversity of relationships and the likelihood that people are no longer close contacts with a strong need for seeing one another. Some family

members will value systems like Family Portals, while others will not. This raises the broader challenge that when designing an always-on video system for the home, it may not be enough to design a one-size-fits-all solution. Clearly some individuals will like such a system, while others may not. Usage will depend greatly on the strength of the relationships that such a system is mediating. In the case of the Family Window, these findings also show that, by chance, the study may have happened to connect families that had a close relationship, while one might have just as easily recruited families with certain members who did not share close relationships. This raises the issue of how one might design an always-on video system like the Family Window or Family Portals that could meet the needs of multiple family members simultaneously, some who may want the system in their home and others who may not. For example, are there ways of showing video of only specific family members? Would this appease the desires of those who do not like such always-on video systems? And is the idea of creating a set of fixed connections (between three families) too rigid, participants perhaps preferring to have different (or intermittent) connections over time to other relations? There is likely a broad spectrum between those who wish to hang out long term (e.g., with a permanent, fixed connection) versus those who (at most) are willing to hang out with others every now and then (e.g., with systems more akin to video chat, which allows briefer connections with a broader community). As more people are involved, the likelihood of a mismatch between their desires will increase.

Audio switching is also more challenging. Family Portals did not include audio, which meant that families who desired it had to do it out of band. We already described how this may not fit teens and those in long-distance relations. Even if the technology did allow for audio, audio switching would be more complex as it would require an interface that allowed people to selectively open and/or close both pairwise and three-way connections (to help them manage privacy).

We can also reflect on Family Portals in relation to our three previously described studies. In the case of long-distance couples, the ability of Family Portals to include multiple video feeds would certainly be valuable. Long-distance couples would likely want more than the two feeds that are supported so that they could place devices in multiple *rooms* of the home; this contrasts the multiple *homes* that Family Portals was originally designed for. Teenagers would be of a similar mindset, only here they would likely value Family Portals connecting friends in different houses, rather than rooms within the same home. Of course, the form factor would have to be more flexible than a tablet on a stand, so that people could easily affix the device to a location that best captures a scene. Again, like the Family Window, teenagers would likely use Family Portals more intermittently rather than as a continuous always-on system. Family Portals would again likely not support the act of sharing major life events for the same reason as the Family Window: activities would easily occur far away from the device (e.g., at the front of an auditorium) and there is only a single camera with no zooming capabilities.

4.3. Perch: A Commercial Always-On Video System

Last, we explore the idea of always-on video and open connections with a more robust commercial system called Perch: a video communications system designed to connect people who share a close relationship, be it family members, friends, or coworkers (available at Perch.co). Users can install and launch the Perch app on any Apple iOS device, including an iPhone, iPad, or iPod Touch. The version of Perch that we studied supported two types of interactions:

(1) ***Video Calling.*** Users could add "friends" to their contact list and video call them (much like Skype and Google+ Hangouts). The receiver of the call saw a video of the caller before she answered it.

Fig. 4. The user interface of Perch once a connection is made to a portal. Image reprinted with the permission of the participant.

(2) ***Always-On Portals.*** In contrast to other commercial video chat systems, users could create a video "portal" that was viewable by select contacts. A portal was an always-on video link that others could choose to connect to at their discretion. Portals were dyadic: they connected only two locations. When not connected, others saw video snapshots of the location that updated once every 5 minutes (for availability awareness). When connected, live video transmitted between both users. Audio turned on and transmitted when the app detected a face in front of the display, regardless of how close the face was to the display. The goal of this feature was to keep a potentially privacy-intrusive audio link off unless a user likely wanted to talk to someone at the remote location. The automation was meant to act as a smooth and hands-free mechanism for moving into conversation. Users could also push a button and leave their own microphone open for a selected period of time (e.g., 15, 20, or 30 minutes).

Figure 4 shows the user interface for Perch once a connection is established. The user's local view is shown in the top right corner of the user interface and the remote view is shown in the main portion of the interface. Perch is ideally used on iOS devices that remain stationary within one's home or workplace. Suggested uses included mounting an older or unused iOS device on the wall, or placing it in a fixed location using a stand. However, one could certainly use Perch intermittently on an iPhone while mobile (akin to Peek-A-Boo [Neustaedter and Judge 2010]).

Perch is different than other commercial video chat systems such as Skype or Google+ Hangouts because it is designed so that users can easily leave video connections open and available for access. It does this through the portal feature, with which users can open their video link so that others can auto-connect to it without anybody answering the call or responding to the connection request. Skype provides a similar auto-answer feature, but it is largely buried in the user interface within menus and settings. Thus,

Table I. Field Trial Participant Demographics (P = Participant)

	Age	Gender	Occupation	Family Members
P1	37–50	F	Software Trainer	Married, 2 children (10, 13 yrs old)
P2	37–50	M	Research Fellow	Married, 3 children (between 1 and 6 yrs old)
P3	26–36	F	UX Designer	Lived alone
P4	26–36	F	PhD Student	Married, long-distance couple
P5	26–36	M	Software Engineer	Lived alone

it is not the primary mode of operation. With Perch, portals are front and center in the user interface. Perch also supports showing availability awareness through video snapshots. Its design is similar to the Family Window; however, Perch differs in that it provides an audio link controlled by face detection. This provides an interesting opportunity for usage (and privacy concerns) that was not studied as part of the Family Window or Family Portals work. Perch also runs on any iOS device. This means that it operates on devices largely used for multitasking. In contrast, the intent behind the design of the Family Window and Family Portals was that they were information appliances that could only operate the video link. Video frame rates are also fast (20–30fps) in Perch compared to the research prototypes (e.g., 2–3fps). Together, these features mean that, with Perch, users are able to adopt and use the system in more nuanced ways (if desired) than the previous designs. For example, they could use Perch from any number of tablets or smartphones and in any location, be it home, work, or while mobile (although still only as a two-way link between two different devices). This provides a broad set of situations, useful for understanding how long-term connections might be used in more realistic situations beyond a more controlled field study in which computer hardware is provided to participants.

Study Methods. We conducted a study of Perch with the goal of understanding how it would be used by first-time users and what impediments they might face in implementation. This was done in two parts.

First, we recruited five participants with varied demographic backgrounds to participate in a field trial. Table I shows details about each of our participants and their family compositions. As can be seen, some participants lived alone, while others had children of varying ages. All participants had one or more iOS devices, including iPhones and iPads, and most households had two to three of these devices. All participants currently used existing video communication technologies, such as Skype, FaceTime, or Google+ Hangouts, to communicate with remote family or friends.

Participants were asked to download and install the Perch application (instructions and remote support were provided) and, over a period of 4 weeks, use the system at least once every day during the first week (and as much as possible in the 3 weeks following). Participants could select with whom they wanted to use the system. These remote friends or family similarly downloaded the system and ran it on their own devices. We sent questions over e-mail to participants periodically during the 4 weeks that asked them about their experiences. Questions explored how the participants used Perch, with whom they used it, what features they used, when and where they used it, and on what devices it was used. We also asked participants to share their most and least favorite experiences with Perch and to let us know if there was anything they would change in Perch. Responses to the questions were sent back to us using short video clips of the participant, akin to a "confessional video." The study concluded with a semi-structured interview asking participants about their overall experience using Perch. We asked them questions that were similar to our periodic e-mail questions. We

Fig. 5. Perch running on an iPad placed in a stand on a counter. Image reprinted with the permission of the participant.

did not collect data from the people to whom our participants connected using Perch. Instead, feedback and descriptions of usage by these people were channeled through our main study participants (this is a limitation of the study). Data were analyzed using a thematic analysis to draw out the overarching themes and findings.

Second, we conducted a field trial focused on our own usage of Perch. Neustaedter (the first author) used the system in his own home to connect with his parents' home (the grandparents of his children) over the course of 6 months. In Neustaedter's home there was Neustaedter, his wife, and three children (ages 7 years, 5 years, and 6 months at the start of usage). In his parents' home, there were two older adults in their late 60s and early 70s. Neustaedter's usage of Perch was similar to that performed with the Family Window; the main difference was that Perch's design was not iterated on based on usage during the trial. In both homes, an iPad was installed and set up on a stand in the home, shown in Figure 5. This stand moved somewhat fluidly between the kitchen and living room in both homes throughout the study period. Perch's Web site suggests mounting an iPad on a wall in the home; however, the families chose not to do this as it would have restricted the movement of the device between rooms. The families purposely situated the iPad on a counter or table such that it could be at a usable height for both adults and children. Overall, this trial allowed us to analyze Perch's design and its usage with an "insider" perspective that drew on our knowledge of media spaces within the home and workplace.

We report on both stages of our evaluation in the following sections.

Calling and Awareness. Participants described using Perch with a mixture of family members and close friends through both *calling* and *always-on portals*. For example, one participant was in a long-distance relationship and used Perch to connect with her distant partner. Sometimes this would be with short video calls; at other times, she would use her iPhone to set up a portal in her house that her fiancé could connect into when he wanted. Another participant used Perch to communicate with his wife and children when he was not at home. To do this, they set up an iPad in a common area of the home. Overall, we found that participants were open to the idea of an always-on video connection. This was largely because they were accustomed to using existing video chat technologies and saw Perch as an extension of this usage. Setting up a portal enabled participants to feel like they were able to maintain an awareness of

activities across their homes as well as communicate with others who lived afar. Thus, usage of Perch for connecting with family or friends was highly valued.

> I would definitely just set up Perch in my house in Chicago and leave it open all the time. I would use it all the time to check in on the house, or my husband, or on my dog. The fact that I don't have to have someone accept the call on the other end is the most useful feature.—Participant 4, Female

> I like to see my parents' place to see what they are up to. For me, it feels like being there again. Sometimes I might not be able to sleep late at night or when I come back from work, it's day time there and I feel the energy of starting a new day from them.—Participant 5, Male

Perch was seen to work particularly well for adults who wanted to connect to their homes when at work or while mobile to check on their children or pets. The always-on nature of the portal meant that parents did not need to wait for a child to answer an incoming video call; the parent could simply connect and look for the child in the video window or call his or her name. Naturally, pets are not able to answer a video call, thus portals enabled pet owners to easily connect to home to see their pets if they had a device positioned in an area where the pet normally was.

> I think it would be good for when my kids come home from school; it's 2 hours before I get home from work. I want to make sure that they're practicing piano or doing their homework. It's more of a way to check up on my kids.—Participant 1, Female

> In theory, I think that it was working well when we had a connection. It's definitely a great concept. I really like being able to dial in at any point so I can check in on my dog. I didn't get to do it that much. It would be in a location where my dog usually is—he'd be there for part of the time and then go off somewhere.—Participant 4, Female

Thus, Perch acted as an awareness device, much like our findings with the Family Window and Family Portals, but it also functioned as a video calling device for conversations of a shorter duration. Our own usage of Perch revealed similar patterns of usage as we had previously seen with the Family Window. We were able to share awareness between homes by periodically glancing at the Perch display. Yet the incorporation of the audio link created new usage patterns and benefits. As stated, audio would turn on if the system detected a face in front of the display. This created situations in which both children and adults would walk up to the display and, after the audio link turned on, call out the name of someone in the remote home. For example, children would walk up to Perch and yell, "Grandma!" If at home, the remote grandmother would then walk over to her own Perch display and start talking to the children. This practice was similar to how one might call out the name of somebody in one's own home to try to find or talk to that person. Now the practice extended across the boundaries of a single home into a second home. Curiously, the increase in video fidelity between the Family Window (∼2–3 fps) and Perch (∼20–30 fps) did not affect our behavior in any noticeable ways.

Participants in our field trial also faced several challenges when using the system, as listed below. These raise important questions for the types of always-on setups that this article has proposed and suggested.

Device Selection and Locations. First, we found challenges related to the personal nature of mobile devices. As mentioned, Perch was designed to run on any iOS device, including iPhones and iPads. While this seemingly opens up an array of possibilities for diverse usage (one reflecting possible design solutions from the previously described studies), we actually found that it limited usage. Smartphones and tablets were typically used by our participants for multitasking purposes (e.g., checking e-mail, surfing the Web) and were often very personal in nature: users kept the device with them and

did not frequently leave it in a stationary location. Because of this behavior, participants most often lacked an extra device that they could leave in one place and dedicate as an always-on Perch portal. People were hesitant to dedicate their iPhone or iPad to running Perch when at home or work, as they required it for periodic usage throughout the day, that is, they still saw their tablets and smartphones as a multitasking device. This is in contrast to the Family Window and Family Portals, which were configured as stand-alone video communications devices, with dedicated tablets not running other software. The prior studies of these systems also saw the families receive a dedicated tablet from the researcher for use within the study; this was not the case in our study of Perch. We had purposely wanted to understand more realistic usage brought on by having participants use their own hardware. What we observed, however, was that the benefit provided by Perch was not enough to overcome participants' desire to use tablets or smartphones as personal, multitasking devices. Yet, at the conclusion of the study, when asked how they would create their ideal setup for Perch if they had additional funds at their disposal, they easily described it as including multiple devices spread throughout a variety of locations.

> I would probably be purchasing multiple iPads (that would be four iPads or something, I guess). In that case, because there would be so many, I'd put one in my home studio, one in my home bedroom, one in my apartment in Vancouver, and one in my workspace in Vancouver. And, actually, one from the house in Chicago would go to my husband's office. If everything is all connected, we'd probably do that as opposed to calling/texting in, if someone was always in a Perch environment.—Participant 4, Female

> I'd probably get the mini iPads and then each kid would get one. When they get home, they would have to turn it on wherever they were during that period of time so I would know where they were. I'd hang one in the kitchen, and one for my mom in her place where I can angle it to see where she always sits. I'd probably even put two in there, so in case she ever fell or something, I can see her.—Participant 1, Female

This illustrates that the desire for a multidisplay, always-on video system for the home is there; however, devices need to be inexpensive enough that they could be easily purchased in larger quantities for placement throughout the home. Alternatively, systems like Perch that can run on any number of mobile devices may be best utilized on hardware that is no longer used on a regular basis by users. For example, old smartphones or tablets may be ideal for placement throughout the home as Perch displays. More broadly speaking, these findings suggest that even though people such as long-distance couples or families with children might want multiple video links within the home as part of an always-on video system, achieving this in practical terms is more difficult.

Privacy and Audio. Second, we saw challenges related to privacy and, specifically, the audio link. The video link within the always-on portals was not seen to be privacy intrusive because people were connecting to those individuals with whom they shared a close relationship. The iOS devices were also placed in locations of the home that showed seemingly mundane activities, for the example, the kitchen and living room. The background conversations that occurred in such areas, however, were easily considered to be privacy-sensitive at times. Sometimes they were even about the people in the remote location that Perch was displaying.

As mentioned, when a face is detected, Perch turns on audio at that end of the connection and a sound is played at *both* locations to alert users. The intention is to allow people to smoothly move into conversation without having to physically touch the display. We found in our trials that, over time, the notification sound easily became unnoticeable, users assumed it was the remote location that had their audio turned on (the same sound played for both homes), or they would try to turn the sound off since

it could became annoying if it repeatedly turned on and off. This latter act would mean that a user did not know if one's Perch client was transmitting audio. We also found that people did not always know who was able to hear conversations at the remote location because Perch only showed a narrow field of view. Like workplace media spaces, people might easily be able to stand outside of the camera's field of view yet still be able to hear background conversations that were being transmitted. Similarly, conversations off-camera could be accidentally captured and transmitted (e.g., a couple arguing in a next-door room).

While these issues certainly point to usability problems that could be fixed through modifications to the face-detection algorithm and alternate feedback mechanisms, they speak to a larger design challenge. When using a video chat system, especially one that provides always-on video or intermittent audio, people want to feel that they are in control over their experience. Naturally, this was found for workplace media spaces as well [Bellotti and Sellen 1993]. For our participants, this equated to being able to easily turn the camera on and off (which participants found was easy to do with Perch), and also control if and when audio was on. Overall, this suggests that automated features that attempt to promote natural conversation patterns should likely be coupled with controls that allow users to override such automation or learn more about how the automation is working. The design goal should be to allow users to feel completely in control of their usage.

Audio vs. Video. Based on our study of Perch, we also recognize the difference between video and audio links in the context of the home and feel that video provides a much less privacy-sensitive situation than audio. This would certainly be different if video links were placed in rooms other than the kitchen or living room. However, in these common areas of the home, shared audio is particularly privacy-intrusive. This is also reflective of the way in which video and audio are designed in Perch. Video is always being transmitted, and this rarely changes. As such, people begin to understand the situation as being one in which video of them is being broadcast to others who may or may not be watching. There is no need to remember if video is on or off, it's just *on*. On the other hand, audio transmission may come and go, requiring people to be able to mentally monitor the situation and recall whether audio is on or off based on system feedback. Always-on audio may bring about its own challenges; however, it would mean that the cognitive effort placed on users to know the state of audio transmission would be eliminated. They would simply know it was on. The unfortunate side effect would be that users would then likely change the nature of their background conversations more permanently to avoid privacy issues.

5. DISCUSSION AND CONCLUSIONS

Our article has stepped through three studies of domestic video chat and three designs of video communication systems with a focus on always-on video or long-term connections. As a whole, we feel that this work presents several main lessons for the design of future domestic video communication systems.

5.1. Moving Beyond Conversations

First, there is a basic lesson that video communication in domestic settings has moved beyond that of just conversations. This is similarly articulated by Kirk et al. [2010] and Brubaker et al. [2012], and we provide additional evidence for it. Families have appropriated commercial video chat systems in many different ways, but the most important difference that we saw was that long-term connections are used to support *sharing everyday life*. For long-distance couples, this is about virtual shared living; for teenagers, this is about hanging out for long periods of time with friends; for families, it is about feelings of connectedness (especially with children); and, for major life events,

this is about sharing special events that have deep and emotional significance. These situations are not first and foremost about conversing, yet the functionality and design of existing video chat systems suggests this usage. This presents a clear need for designers and researchers to think about new paradigms for the design of video chat systems. Open connections are not for everybody and every relationship. Some people will value open connections, while others may not (also found by Kirk et al. [2010] for home settings and Bellotti and Dourish [1997] for work settings). Designers of such technologies will need to think carefully about the people, relationships, and situations for which they are designing and design accordingly.

5.2. Comparing the Workplace to the Home

Second, we have shown that long-term connections in the home generally support different needs than long-term connections in the workplace. In the home, the focus is on using awareness to produce feelings of presence and closeness, often coupled with strong emotions between distance-separated family members. This comes from sharing aspects of everyday life over the video link. Thus, it is also about building, maintaining, and strengthening relationships. In the workplace, the focus of long-term connections is generally on using awareness to foster conversations and casual interactions, which in turn help support group work and collaborations [Fish et al. 1990; Bellotti and Sellen 1993]. Thus, these video links share aspects of "everyday life" as well, but it is everyday *work life* [Sellen and Harper 1997; Harrison et al. 1997; Bellotti and Dourish 1997] and not one's personal life (as is the case for open domestic connections). Work and home environments are very different in terms of their setting, environment, and activities. For example, office spaces are normally brightly lit compared to the poorly lit rooms in which one might use an open video connection at home. There are also different norms and privacy expectations [Kirk et al. 2010]. For example, at work one is expected to dress and behave a particular way, while at home these norms are arguably more relaxed and more greatly map to one's personal desires [Neustaedter and Greenberg 2003]. Thus, open connections for both the workplace and home are focused on feelings of co-presence and the maintenance of social relationships, but the nuances of these relationships and the practices and expectations of the two locations differ greatly. This suggests that video chat systems designed for the workplace may not work well for domestic settings and activities (also suggested by Kirk et al. [2010]).

5.3. One-Size-Fits-All Solutions Do Not Work

Third, system designs for supporting long-term domestic video connections may need to be designed differently for different locations or situations. Currently, commercial video chat systems are a one-size-fits-all solution. The software and hardware is the same regardless of where or how it is being used. Even systems like the Family Window, Family Portals, and Perch are designed largely with a one-size-fits-all mentality. Different designs would be valuable for different locations, populations, and activities. This might include unique designs for rooms within the home such as the kitchen, living room, bedroom, or bathroom. It might also include unique designs for the outdoors that remove the need to hold a video-streaming device. Different device designs are also needed for locations that typically host major life events such as auditoriums, churches, halls, as the like. One possible solution is systems that incorporate multiple camera streams: for example, some long-distance couples would value video systems that provide streams from different rooms in the home. The same may be needed when families share major life events that occur in large buildings or rooms such as churches or auditoriums. Some families may value multiple cameras/displays if they have multiple children who want to share in a video call at the same time [Oduor and Neustaedter 2014]. Yet multiple cameras may bring about their own challenges. For

example, a single camera may be enough for some families, especially if it is left always on, since it allows them to share an awareness of their life with a remote home while balancing privacy concerns about capturing "too much." A single camera may also be good enough for teenagers since they often want to share a restricted view. Again, this illustrates that there will not be one single design solution that will work for every user in every situation.

5.4. Dedicated Devices

Fourth, systems should move away from the current notion of an app running on multitasking hardware (such as a phone, tablet, laptop, or workstation computer) to instead envisaging a dedicated (and low-cost) information appliance. Quite simply, people will be tempted to use a nondedicated device for other purposes. Envisioning such devices also means that its form factor(s) can be altered significantly, for example, to include stands, to have a look and feel that fits the atmosphere, to comprise multiple parts such as a base station with multiple wireless camera feeds, and so on. Envisioning such devices as information appliances means that they can have quite different—and even highly specialized—designs that fit both the environment and the people involved. Such systems should still allow connections from traditional devices, as people may still want to link into the system when on the move. Like our work, Kirk et al. [2010] similarly suggest that the additional mobility of devices throughout the house is desired (teenagers may be the exception) along with designs focused on multiparty usage and stand-alone or appliance designs.

5.5. Audio Control

Fifth, system designers should carefully think about audio control as a part of long-term connections. Audio is beneficial to support intermittent conversations that may come and go while a long-term video connection is open. Yet it is also challenging because audio can be picked up by a microphone from a far away distance and it is difficult to know who at the remote end of a connection can hear it. Our study of Perch found that audio was more privacy-intrusive than video because the visible activities in the home were typically mundane things occurring in the kitchen or living room. If automated control of audio is to be used, designers must carefully think about what interaction mechanisms are most appropriate for users to feel like they are in control over an audio link. Feedback of when an audio link is on must also be understandable with little cognitive effort to recall the state of the link. In situations that might occur outside of the home, such as the sharing of major life events, the challenge becomes how to transmit audio of an event's focal point (e.g., the wedding ceremony at the front of the room), rather than background conversation that might happen to occur near a video system's microphone.

5.6. Expressions of Intimacy

Sixth, system designers should think about the ways in which video communication systems can support expressions of intimacy over distance. In the simplest case, intimacy is about 'being' with someone over distance through a video link. This was the case for many of the long-distance couples in our study. Intimacy may also come from one's ability to gesture in particular ways that are indicative of physical expressions of intimacy. For example, one may blow a kiss, create a gesture of a hug, or look into the eyes of a remote partner. Even these simple physical gestures of intimacy are awkward and challenging because of very basic technical challenges with existing video chat systems such as poor lighting, discrepancies between the placement of cameras and displays, the nonlifelike size of displays, and so on. There is also the problem that current commercial video chat systems turn physical expressions of intimacy into visual

representations of them, for example, a hug over video chat becomes a video clip of a one-sided hug. This severely limits people's ability to physically connect. There is no obvious solution to these richer acts containing true physical touch, and it remains an open design challenge. Perhaps research solutions that merge two video spaces into one could help. For example, the OneSpace system [Ledo et al. 2013] fuses video images of two distance spaces into a single shared, depth-corrected video, in which people from both sites inhabit that single scene. While there are other possibilities, designers would need to avoid uncanny designs and social awkwardness with any solution.

Last, we hope that the study reviews and analysis in this article will help to provide a foundation for the way other researchers and designers think about designing domestic video chat systems to support new and interesting activities over distance. There is likely a wealth of relationships and situations for which people would value using long-term video chat connections. We have certainly only scratched the surface.

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REFERENCES

M. Ames, J. Go, J. Kaye, and M. Spasojevic. 2010. Making love in the network closet: The benefits and work of family videochat. In *Proceedings of the CSCW.* ACM, New York, NY.

J. Bardzell and S. Bardzell. 2011. Pleasure is your birthright: Digitally enabled designer sex toys as a case of third-wave HCI. In *Proc. CHI.* ACM, New York, NY.

V. Bellotti. 1996. What you don't know can hurt you: Privacy in collaborative computing. In *Proceedings of HCI'96*. Springer, 241–261.

V. Bellotti. 1998. Design for privacy in multimedia computing and communications environments. In Agre, P. E. and Rotenberg, M. (eds.). *Technology and Privacy: The New Landscape*. MIT Press, Cambridge, MA, 63–98.

V. Bellotti and P. Dourish. 1997. Rant and RAVE: Experimental and experiential accounts of a media space, In Finn, K., Sellen, A., and Wilbur, S. (eds). *Video Mediated Communication.* Lawrence Erlbaum Associates, Mahwah, NJ, 245–272.

V. Bellotti and A. Sellen. 1993. Design for privacy in ubiquitous computing environments. In *Proceedings of the 3rd European Conference on Computer-Supported Cooperative Work (ECSCW'93)*, Kluwer Academic, 77–92.

M. Boyle, C. Neustaedter, and S. Greenberg. 2009. Privacy factors in video-based media spaces. In Harrison, S. (ed.). *Media Space: 20+ Years of Mediated Life*. Springer, New York, NY.

J. Brubaker, G. Venolia, and J. Tang. 2012. Focusing on shared experiences: moving beyond the camera in video communication. In *Proceedings of DIS*. ACM, New York, NY.

S. Bly, S. Harrison, and S. Irwin. 1993. Media spaces: Bringing together a video, audio and computing environment. *Communications of the ACM* 36, 1, 28–45.

T. Buhler, C. Neustaedter, and S. Hillman. 2012. How and why teenagers use video chat. In *Proceedings of CSCW*.

S. Conversy, W. Mackay, M. Beaudouin-Lafon, and N. Roussel. 2003. VideoProbe: Sharing pictures of everyday life. In *Proceedings of IHM 2003*. ACM, New York, NY.

J. Coutaz, F. Bérard, E. Carraux, and J. Crowley. 1998. Early experience with the Mediaspace CoMedi. In *Proceedings of the IFIP Working Conference on Engineering for Human-Computer Interaction (EHCI'98)*.

P. Dourish. 1993. Culture and control in a media space. In *Proceedings of the ECSCW 1993.* Springer, 125–137.

P. Dourish and S. Bly. 1992. Portholes: Supporting awareness in a distributed work group. In *Proceedings of CHI.* ACM, New York, NY.

P. Dourish, A. Adler, V. Bellotti, and A. Henderson. 1996. Your place or mine? Learning from long-term use of audio-video communication. *Journal of Computer Supported Cooperative Work* 5, 1, 33–62.

J. Filho, K. Inkpen, and M. Czerwinski. 2009. Image, appearance and vanity in the use of media spaces in videoconferencing. In *Proceedings of GROUP.* ACM, New York, NY.

R. Fish, R. Kraut, and B. Chalfonte. 1990. The VideoWindow system in informal communications. In *Proceedings of CSCW 1990.* ACM, New York, NY.

A. Forghani and C. Neustaedter. 2014. The routines and needs of grandparents and parents for grandparent-grandchild conversations over distance. In *Proceedings of CHI.* ACM, New York, NY.

S. Greenberg and M. Rounding. 2001. The notification collage: Posting information to public and personal displays. In *Proceedings of CHI*. ACM, New York, NY.

S. Greenberg and C. Neustaedter. 2012. Shared living, experiences, and intimacy over video chat in long distance relationships. In Neustaedter, C., Harrison, S., and Sellen, A. (eds). *Connecting Families: The Impact of New Communication Technologies on Domestic Life*. Springer, New York, NY.

S. Harrison. 2009. *Media Space: 20+ Years of Mediated Life*. Springer, New York, NY.

S. Harrison, S. Bly, S. Anderson, and S. Minneman. 1997. The media space. In Finn, K., Sellen, A., and Wilbur, S. (eds.). *Video Mediated Communication.* Lawrence Erlbaum Associates, Mahwah, NJ, 273–300.

D. Hindus, M. S. Ackerman, S. Mainwaring, and B. Starr. 1996. Thunderwire: A field study of an audio-only media space. In *Proceedings of CSCW 1996.* ACM, New York, NY.

H. Hutchinson, W. Mackay, B. Westerlund, B. Bederson, A. Druin, C. Plaisant, M. Beaudouin-Lafon, S. Conversy, H. Evans, H. Hansen, N. Rouseel, B. Eiderback, S. Lindquist, and Y. Sundblad. Technology probes: inspiring design for and with families. In *Proceedings of CHI 2003.* ACM, New York, NY, 17–25.

K. Inkpen, H. Du, A. Roseway, A. Hoff, and P. Johns. 2012. Video kids: Augmenting close friendships with asynchronous video conversations in VideoPal. In *Proceedings of CHI.* ACM, New York, NY.

G. Jancke, G. Venolia, J. Grudin, J. J. Cadiz, and A. Gupta. 1996. Linking public spaces: Technical and social issues. In *Proceedings of CSCW*. ACM, New York, NY.

T. K. Judge and C. Neustaedter. 2010. Sharing conversation and sharing life: Video conferencing in the home. In *Proceedings of CHI.* ACM, New York, NY.

T. K. Judge, C. Neustaedter, and A. F. Kurtz. 2010. The Family Window: The design and evaluation of a domestic media space. In *Proceedings of CHI.* ACM, New York, NY.

T. Judge, C. Neustaedter, S. Harrison, and A. Blose. 2011. The Family Portals: Connecting families through a multifamily media space. In *Proceedings of the CHI*. ACM, New York, NY.

D. Kirk, A. Sellen, and A. Xianc. 2010. Home video communication: Mediating closeness. In *Proceedings of CSCW.* ACM, New York, NY, 135–144.

R. Kraut, C. Egido, and J. Galegher. 1988. Patterns of contact and communication in scientific observation. In *Proceedings of CSCW.* ACM, New York, NY, 1–12.

D. Ledo, B. A. Aseniero, S. Greenberg, S. Boring, and A. Tang. 2013. OneSpace: Shared depth-corrected video interaction. In *Proceedings of the ACM CHI 2013 Extended Abstracts (CHI'13*). ACM, New York, NY.

K. Lipartito. 2003. Picturephone and the Information Age: The social meaning of failure. *Technology and Culture*, 44, 1, 50–81.

M. Mantei, R. Baecker, A. Sellen, W. Buxton, T. Milligan, and B. Wellman. 1991. Experiences in the use of a media space. In *Proceedings of CHI 1991.* ACM, New York, NY.

M. Massimi and C. Neustaedter. Moving from talking heads to newlyweds—exploring video chat use during major life events. In *Proceedings of DIS.* ACM, New York, NY.

G. McEwan and S. Greenberg. 2005. Supporting social worlds with the community bar. In *Proceedings of GROUP.* ACM, New York, NY.

H. Nakanishi, K. Tanaka, and Y. Wada. 2014. Remote handshaking: touch enhances video-mediated social telepresence. In *Proceedings of CHI.* ACM, New York, NY.

A. Noll. 1992. Anatomy of a failure: Picturephone revisited. *Telecommunications Policy* 16, 4, 307–316.

C. Neustaedter. 2013. My life with always-on video. *Electronic Journal of Communication: Special Issue on Video Conferencing, Communication Institute for Online Scholarship (COIS)* 23, 1.

C. Neustaedter and S. Greenberg. 2003. The design of a context-aware home media space for balancing privacy and awareness. In *Proceedings of UbiComp 2003*. Springer-Verlag.

C. Neustaedter and S. Greenberg. 2012. Intimacy in long-distance relationships over video chat. In *Proceedings of CHI.* ACM, New York, NY.

C. Neustaedter and T. K. Judge. 2010. Peek-a-boo: The design of a mobile family media space video. In *Proceedings of UbiComp.* ACM, New York, NY.

C. Neustaedter, T. Judge, A. Kurtz, and E. Fedorovskaya. 2010. The Family Window: Connecting families over distance with a domestic media space. In *Video Proceedings of the Conference on Computer Supported Cooperative Work (CSCW'10)*. ACM, New York, NY.

C. Neustaedter, T. Judge, and P. Sengers. Autobiographical design in the home. In Judge, T. and Neustaedter, C. (eds.) *Studying and Designing Technology for Domestic Life: Lessons from Home*. Morgan Kaufmann, Burlington, MA.

C. Neustaedter and P. Sengers. 2012. Autobiographical design in HCI research: Designing and learning through use-it-yourself. In *Proceedings of the Conference on Designing Interactive Systems (DIS'12)*. ACM, New York, NY.

E. Oduor and C. Neustaedter. 2014. The Family Room: A multi-camera, multi-display family media space. *Video Proceedings of the CSCW Conference on Computer Supported Cooperative Work and Social Computing (CSCW'14)*. ACM, New York, NY.

K. O'Hara, A. Black, and M. Lipson. 2009. Media spaces and mobile video telephony. In Harrison, S. (ed.). *Media Space: 20+ Years of Mediated Life*. Springer, New York, NY.

C. Pang, C. Neustaedter, B. E. Riecke, E. Oduor, and S. Hillman. 2013. Technology preferences and routines for sharing health information during the treatment of a chronic illness. In *Proceedings of CHI.* ACM, New York, NY.

J. Procyk, C. Neustaedter, C. Pang, A. Tang, and T. K. Judge. 2014. Exploring video streaming in public settings: Shared geocaching over distance with mobile video chat. In *Proceedings of CHI.* ACM, New York, NY.

H. Raffle, R. Ballagas, G. Revelle, H. Horii, S. Follmer, J. Go, E. Reardon, K. Mori, J. Kaye, and M. Spasojevic. 2010. Family story play: Reading with children. In *Proceedings of CHI.* ACM, New York, NY.

S. Rintel. 2013. Video calling in long-distance relationships: The opportunistic use of audio/video distortions as a relational resource. *Electronic Journal of Communication: Special Issue on Video Conferencing, Communication Institute for Online Scholarship (COIS)* 23, 1.

A. Sellen and R. Harper. 1997. Video in support of organizational talk. In Finn, K., Sellen, A., and Wilbur, S. (eds.). *Video Mediated Communication.* Lawrence Erlbaum Associates, Mahwah, NJ, 225–244.

A. Voida, S. Voida, S. Greenberg, and H. A. He. 2008. Asymmetry in media spaces. In *Proceedings of CSCW*.

S. Whittaker, D. Frohlich, and O. Daly-Jones. 1994. Informal workplace communication: What is it like and how might we support it? In *Proceedings of CHI.* ACM, New York, NY, 131–137.

S. Yarosh, S. Cuzzort, H. Müller, and G. D. Abowd. 2009. Developing a media space for remote synchronous parent-child interaction. In *Proceedings of IDC.* ACM, New York, NY.

S. Yarosh, A. Tang, S. Mokashi, and G. Abowd. 2013. "Almost touching": Parent-child remote communication using the sharetable system. In *Proceedings of CSCW.* ACM, New York, NY.

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