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Mobile Video Conferencing for Sharing Outdoor Leisure Activities Over Distance

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Video communication systems work relatively well for family members and friends when they want to converse with each other between their homes. Yet it is much more challenging to share activities using mobile video conferencing in outdoor settings. We explored the design of mobile video conferencing systems that focused on allowing family and friends to participate in outdoor leisure activities together over distance. We created and studied two technology probe setups: shared geocaching and shared bicycling. Both used mobile cameras and streamed audio and video between remote family members or friends as they participated in the activities. Through these design and study explorations, we explore how family and friends make use of mobile video during leisure activities, what elements are important for the design of such systems, and how mobile video for outdoor leisure activities compares and contrasts to video calling in the home and, more generally, while mobile. Our research points to design considerations around camera views, when and how audio and video should be presented, and the privacy concerns of users and how to balance them with the benefit of the technology.

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Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/HHCI.

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1. INTRODUCTION

Video communication systems like Skype or Apple's FaceTime are now a part of many families' lives as a medium for connecting with family members or friends who live far away (Brubaker, Venolia, & Tang, 2012; Judge, Neustaedter, & Kurtz, 2010; Kirk et al., 2010). Here the focus is often on conversing with one another or sharing activities between homes (Brubaker et al., 2012; Judge et al., 2010; Kirk et al., 2010; Neustaedter & Greenberg,

2012). We are also now seeing the emergence of mobile video conferencing, where family or friends can connect at any point in time to share their experiences from any location; however, this type of behavior is still not very common given the limitations and challenges with existing mobile video conferencing systems and network connectivity (Jones, Witcraft, Bateman, Neustaedter, & Tang, 2015). Initial research efforts have explored how to design better mobile video conferencing to aid the sharing of activities over distance between family and friends, where one person watches another do an activity from home, for example, viewing a sports practice or "virtually" attending a picnic (Inkpen, Taylor, Junuzovic, Tang, & Venolia, 2013). Research has also explored shared outdoor activities through audio feeds (Mueller, O'Brien, & Thorogood, 2007; Mueller et al., 2010). Our research builds on this work to explore how family members and friends jointly share in outdoor leisure activities where new forms of mobile video *and* audio—wearable and mounted video cameras—connect locations and activities. Here we explore two main types of activities: parallel experiences and mixed experiences.

Parallel experiences involve two distance-separated people doing the same activity in parallel, together, rather than one person passively watching the activity from home. Both people are in their own location where video and audio connects the two. This reflects many situations in life where colocated people go out and do an activity, in parallel (e.g., walking, running, playing sports, sightseeing). Across the video communications literature, we see a lack of focus on such activities. *Mixed* experiences involve one person doing an activity while another is at home watching that person do the activity and conversing with the person as they do so. Again, video and audio streaming connects the two people between their locations. The mixed experience represents cases where a family member may not be able to leave home because of health issues (Pang, Neustaedter, Riecke, Oduor, & Hillman, 2013) or where one person wants to show something to remote family or friends while out and about (e.g., akin to a virtual photo walk; Virtual Photo Walks: www.virtualphotowalks.org). For example, this might arise if a person has recently moved to a new location or is visiting somewhere. Such experiences have been focused on more in the related literature (e.g., Inkpen et al., 2013; Jones et al., 2015), and we expand on the types of activities being shared.

Across these experience types, our research focus was on understanding how mobile video calls manifest themselves when family and friends are participating in outdoor leisure activities and how various attributes of the design affect the experience. We explored the ways in which mobile video is used by family and friends during such activities, how the nature of the activities affects various aspects of the video call and connection, and how people's behaviors compare and contrast to more typical video calls in homes and in mobile situations. We investigated these topics by using commercial software and hardware to create and study two technology probes (Hutchinson et al., 2003). The first, Shared Geocaching, explores a parallel experience. It uses a two-way video exchange via a smartphone and head-mounted mobile camera to allow remote partners to geocache in parallel. Figure 1 shows an example case where video and audio is streaming between two friends who are geocaching in different locations. Geocaching is a real-world treasure hunt game in which players look for hidden containers using GPS coordinates. It includes walking and hiking, which are typical leisure activities.

FIGURE 1. Shared Geocaching: Two people geocache in different locations and share video via a small camera mounted to glasses.

***Note*. Video is selectively available on a smartphone worn in an armband.**

The second technology probe, Shared Bicycling, involves parallel or mixed experiences. It uses off-the-shelf commercial hardware to stream audio and video between bicycle riders using two bicycle-mounted smartphones that provide first- and third-person views to the remote partner. Figure 2 shows Shared Bicycling as a parallel experience in which two people are going for a bicycle ride at the same time but in two different locations. They share video and audio using smartphones mounted on the bicycle. Figure 3 shows Shared Bicycling as a mixed experience in which one person rides a bicycle and streams video and audio to a person at home, who watches and talks to the rider.

We conducted in-the-wild studies of both Shared Geocaching and Shared Bicycling in which partners used the technology probes while doing the respective activities. For Shared Bicycling, half of the participants did it as a mixed experience and half did it as a parallel experience. Overall, our results show that most participants highly valued the experience of connecting with a family member or friend to engage in a leisure activity together over distance, be it as a parallel or mixed experience. Both Shared Geocaching and Shared Bicycling created an intimate shared experience between partners; they felt especially close to one another despite being far apart and doing the activity amidst the other everyday happenings going on around them. These feelings strongly related to the private viewing and listening found within the mobile video conferencing system. Yet there were design and social challenges that arose during the study of the technology probes that point to new ways of thinking about and designing for "camera work," the use of selectively available video and continuously available audio, varying levels of

FIGURE 2. Shared Bicycling as a Parallel Experience: Two people ride bicycles in different locations and share video via smartphones mounted on the bicycles.

FIGURE 3. Shared Bicycling as a Mixed Experience: One person rides a bicycle and streams video to a person watching from home.

connectivity and engagement, and privacy challenges that emerge from different types of camera views as well as environmental factors. We detail these opportunities for design and sensitize researchers and designers to the design factors that are important for mobile video conferencing systems that aim to support shared outdoor leisure activities over distance.

2. RELATED WORK

2.1. Video-Mediated Communication in the Home

In recent years, video-mediated communication has been adopted by many distance-separated family and friends for staying connected (Ames, Go, Kaye, & Spasojevic, 2010; Brubaker et al., 2012; Judge & Neustaedter, 2010). Studies have shown that the feelings of closeness provided by video-mediated communication systems can help families and friends be willing to accommodate distance separation from their loved ones (Brubaker et al., 2012). During video calls, families enjoy conversing because they can then see each other, though they often face many technical challenges in maintaining a connection (Ames et al., 2010; Kirk et al., 2010; O'Hara, Black, & Lipson, 2006). Some people face privacy concerns about how they look or what is shown over the video link (Neustaedter et al., 2015). People also often feel a sense of obligation to stay in the video camera's view during calls (Harper, Rintel, Watson, & O'Hara, 2017; Kirk et al., 2010), where conversations can be easily constrained to fit topics that lend themselves to a video call (e.g., what can easily be shown; Harper et al., 2017). Although family and friends value conversations over video chat, many people find them inadequate in creating feelings of copresence, and individuals often desire to move beyond conversation-only video communications to engage in shared activities such as attending parties, watching different types of media, playing games together, or sharing experiences (Brubaker et al., 2012; Forghani, Venolia, & Inkpen, 2014; Massimi & Neustaedter, 2014). For example, long-distance couples like to share their daily routines when at home (Neustaedter & Greenberg, 2012); grandparents and grandchildren share bedtime routines (Forghani & Neustaedter, 2014); preteens and teenagers share their homework time, playtime, and leisure activities (Buhler, Neustaedter, & Hillman, 2013; Inkpen, Du, Roseway, Hoff, & Johns, 2012); and children get help with homework from nonresident parents (Yarosh, Cuzzort, Müller, & Abowd, 2009). Thus, although video chat systems are sometimes constraining in their design, people are good at exploiting the technology to perform a range of activities over video chat.

Researchers have designed and explored a variety of prototype systems in an effort to better support the needs of family and friends during video communications. These can be classified as designs supporting direct conversation (Vutborg, Kjeldskov, Paay, Pedell, & Vetere, 2011), focused activities (Raffle et al., 2010; Yarosh et al., 2009; Yarosh, Inkpen, & Brush, 2010), and viewing passive activities through always-on video (Judge, Neustaedter, Harrison, & Blose, 2011; Judge et al., 2010; Neustaedter et al., 2015). Systems have included small, tablet-sized displays (Judge et al., 2011); displays embedded in objects (Raffle et al., 2010); and even large, life-size telepresence projections meant to be more immersive (Pejsa, Kantor, Benko, Ofek, & Wilson, 2016). Studies of these systems have emphasized the continued value in seeing a remote loved one and the ability to perform a range of activities *while* a video link is open, where one need not always stay in front of their camera (Judge et al., 2011; Judge et al., 2010; Neustaedter et al., 2015; Yarosh et al., 2009). Some research has even called for the ability to have multiple

cameras or viewpoints to reduce the need for copious amounts of camera work and to overcome the challenges associated with small video displays as a result of smartphones and tablets (Neustaedter et al., 2015). We build on this related work to explore how family members and friends make use of video chat systems as part of outdoor leisure activities, comparing our findings to the aforementioned related work. Our work extends the types of shared activities that can be performed by family and friends over distance when mobile video calling is readily available. The main difference is that the aforementioned studies and designs focus on indoor contexts; our research moves outside of the home to explore video calling in outdoor settings.

2.2. Mobile Video and Outdoor Experiences Over Distance

Several studies and research prototypes have explored the use of mobile video chat along with the sharing of outdoor experiences between family and friends, the focus of our research. First, studies of mobile video in shopping, restaurant, museum, and touring situations show the difficulties with camera work: the continual orientation and placement of the mobile video camera to provide good views for remote users (Inkpen et al., 2013; Jones et al., 2015; Rae, Venolia, Tang, & Molnar, 2015). People hold and move mobile phones somewhat awkwardly in these situations to try to share the scene with a remote person (Jones et al., 2015). Remote users often want more control over their own view, the ability to gesture at things in the scene (Jones et al., 2015), a sense of spatial context (Jones et al., 2015; Kim, Junuzovic, & Inkpen, 2014), and the ability to see both the environment and camera handler at the same time (Inkpen et al., 2013). Local users desire hands-free cameras that are easily moveable and support camera zooming (Inkpen et al., 2013; Neustaedter & Judge, 2010). Camera work can also involve thinking about what should or should not be shown on camera. Studies of mobile video chat in public settings have shown that bystanders react differently to wearable cameras compared to cameras on smartphones, often being more concerned about their privacy with wearables; thus, users must be careful about who and what they stream over video when in public settings (Nguyen, Bedford, Bretana, & Hayes, 2011; Singhal et al., 2016). People are also concerned about audio being overheard in public settings during video calls on mobile devices (e.g., while commuting or at work) and the viewing of video screens by bystanders (O'Hara et al., 2006). Our studies further explore privacy as a potential concern during leisure activities, whereas our technology probes build on and explore the aforementioned design suggestions where we consider first- and third-person camera views. The combination of these viewpoints has not been explored in the aforementioned research.

Second, researchers have also studied how mobile technology can support parallel experiences over distance through shared physical activities in the outdoors, albeit the number of explorations is fewer. For example, Jogging Over Distance was a prototype system that allowed two geographically separated joggers to jog together where they heard spatialized audio from the remote jogger; this helped create a sense of connection (Mueller, Agamanolis, & Picard, 2003; Mueller et al., 2007; Mueller et al., 2010; O'Brien & Mueller, 2007). There is also a broader range of research on the use of exertion interfaces

to support sports activities over distance (Mueller, Agamanolis, Gibbs, & Vetere, 2009; Mueller et al., 2003). This work shows the potential for supporting physical leisure activities over distance as a means to increase social bonding (Mueller et al., 2009; Mueller et al., 2003). Like our work, video and audio feeds are used to connect remote users and locations, though the context is typically indoors and in a fixed location (Mueller et al., 2009; Mueller et al., 2003). In comparison, our research explores outdoor activities that change in their location (e.g., walking, bicycling). This allows us to study different factors stemming from mobility, such as privacy issues with varying bystanders and safety concerns from being mobile and using video calls at the same time.

Third, although not specifically focused on family and friend communication, researchers have investigated live video streaming from outdoor settings between users and the general public. Here we see that, again, producing live video broadcasts can be difficult because of the amount of camera work involved; however, people still enjoy broadcasting a range of things including tours, performances, social events, and "sudden situations" (Juhlin, Engström, & Reponen, 2010). Studies of Periscope and Meerkat found that streams were seen as depictions of a person's life where the streamer went to great efforts to be "authentic" and to create a personal brand (Tang, Venolia, & Inkpen, 2016). The Mobile Vision Mixer allowed multiple people to broadcast live video of an event from multiple cameras when tracking the viewpoints of cameras becomes important (Engström, Perry, & Juhlin, 2012). In a similar setup, researchers learned that camera orientation and varying angles are important for mobile video streaming (Engströöm, Zoric, Juhlin, & Toussi, 2012). There is also the recognition that the goals of an amateur cameraperson are typically to have fun and to enjoy the event or activity, yet this is juxtaposed with the needs of the remote viewer, which are often focused on good camera views (Engstrom et al., 2012b; Reeves et al., 2015). This highlights the dual role that most mobile camera streamers must take on; they are at the same time a cameraperson and a participant in the activity. Our research builds on this work to explore a somewhat automated form of camera work using mounted or wearable cameras; however, our focus is on sharing video between people with existing relationships rather than strangers. Most of the research on live streaming in outdoor settings focuses on the public consumption of video.

2.3. Family Leisure and Cohesion

Our research explores leisure activities between family members and friends that might be performed over a mobile video conferencing system. Such activities have been shown to be important for family life as a means to improve family cohesion, social bonding, and conflict resolution skills (Olson, 1986; Wells, Widmer, & McCoy, 2004). Shared family leisure activities have been shown to be critical for establishing strong family relationships and life satisfaction (Agate, Zabriskie, Agate, & Poff, 2009; Zabriskie & McCormick, 2003). Outdoor recreation, in particular, has been shown to help maintain and increase family cohesiveness (West & Merriam, 2009). We also know that people do activities for the sheer purpose of enjoyment and pleasure (Brown & Juhlin, 2015). That

is, they are not necessarily thinking of improving family relationships when they pursue a leisure activity. Family leisure falls into two categories: core and balance activities (Freeman & Zabriskie, 2003). Core activities are the common, everyday low-cost activities that family members normally do together when living in the same location (e.g., eating together, playing games, walking; Freeman & Zabriskie, 2003). Balance activities are the less frequent activities that typically occur outside of the home and are out of the ordinary, have an element of novelty, and stand apart from everyday life (e.g., new shared activities, trips, vacations; Freeman & Zabriskie, 2003). Balance activities help family members work as a unit and help foster the family's skills in adapting to new situations (Freeman & Zabriskie, 2003). Leisure activities can be either serious or casual: Serious activities involve some extensive training, and casual activities require less commitment and effort (Stebbins, 1997). Casual activities are more apt to involve conversation, involve play, and be focused on pleasure and enjoyment (Stebbins, 1997). In our study, we focus on two activities—geocaching and bicycling. Depending on a person's experience with these activities, they could be considered either core or balance activities. Most people would consider them to be casual activities.

3. SHARED GEOCACHING TECHNOLOGY PROBE

The goal of our research was to understand how people experience mobile video during outdoor leisure activities and how the design of mobile video systems affects the experience. Although there are a multitude of leisure activities that one could pick to study, we selected geocaching as our first focal activity. Geocaching is a GPS-based treasure hunt in which players search for hidden containers in urban centers, parks, and forests (Kelley, 2006). We selected geocaching because it includes walking or hiking, which are activities with relatively low physical thresholds in which people often converse during the activity (Chavez, Courtright, & Schneider, 2004; O'Hara, 2008). Thus, it is a social activity. Geocaching also includes navigation and looking for specific items that are hidden by others playing in the game (Neustaedter, Tang, & Judge, 2010, 2013; O'Hara, 2008). Thus, at times the activity becomes much more goal oriented than straightforward walking where people are trying to achieve a fairly targeted goal (finding the geocache container). This can include tightly coupled collaboration if people are hunting for geocaches together. Again, this means the activity can be highly social. It also allows us to explore a situation in which there is a mixture of general walking around, plus more targeted "work" at times. When people narrow in on the general area they are searching for and begin looking for the geocache container, geocaching contains a level of stealth as players do not want nonplayers (called *muggles*) to know about the game. This is intriguing, for it means that part of the time one is geocaching, the activity is done in a manner to avoid suspicion and observation.

We extended the idea of geocaching to be a shared activity over distance by connecting two players using a mobile video conferencing system where each hunts for their own geocache but can help the other person. To date, nobody has explored remote geocaching experiences aside from research on geocaching in virtual worlds (Lam

& Neustaedter, 2013), which is quite different from our focus. We called our technology probe *Shared Geocaching*, and it is shown in Figure 4. The probe included a wearable mobile video camera that captured the wearer's field of vision by being attached to an article of clothing such as a hat or a pair of glasses, shown in Figure 4 (bottom left). We used a Looxcie 2 camera and an ordinary pair of sunglasses to prototype the experience; although the prototype was crude looking, it allowed us to rapidly explore the technology setup and related experience. Using a Bluetooth connection and a specially designed smartphone application (by Looxcie), the camera transmitted live streaming video through a local smartphone, at 640 × 480 resolution and 24 frames per second, in the best case, to the remote viewer over the Internet. At times the camera resolution was algorithmically reduced if network bandwidth became constrained. The camera captured and transmitted audio to the remote person, so the users could talk to one another throughout the experience. Talking was done through wired earbuds with a built-in microphone.

We modified a wearable runner's armband to hold a smartphone that showed the remote user's video (Figure 1, right). This contrasts a head-mounted display (e.g., smartphone attached to a helmet, or augmented-reality glasses), as we wanted to make video selectively available to users. Thus, they could choose when to look at the remote user's video feed by lifting their arm and looking at the smartphone display. This also meant that the video feed did not obscure a person's normal vision. Given the placement of the camera at head level and facing outward, the technology probe broadcasts a first-person video to a remote user's smartphone. Thus, a view of the user's face is never shown; this contrasts

FIGURE 4. The Shared Geocaching technology probe. Top left: the remote view; bottom left: the camera attached to glasses; right: user looking at the remote camera view.

FIGURE 5. A user (left) streams the video on the right to a remote person.

typical video calling in home settings, where people's faces are often on camera. Figure 5 shows the user on the left and the view being streamed to the remote user on the right.

4. SHARED GEOCACHING STUDY DESIGN

In our study, two people geocached in different locations, where each hunted for his or her own geocaches but could selectively see the other person's view and converse via an audio link. Thus, people could help each other out as needed, or simply "be together" while doing the activity.

4.1. Participants and Recruitment

We recruited 16 people for our study—eight pairs of friends or family members—via advertisements on online geocaching forums and within our university community. Ten of 16 participants were between 20 and 30 years old, two were between 40 and 50, and four were between 50 and 60; thus, our participants generally represented a young demographic. Occupations included a pharmacy technician, special education teacher, journalist, videographer, retail salesperson, and students. Eleven people frequently participated in outdoor activities, and 10 said that they often went on hikes or walks with friends. All but one participant was familiar with the concept of geocaching, though 10 had never found any geocaches. Three people had found between one and four geocaches, one had found more than 10, one had found more than 500, and another had found more than 1,000 geocaches. These details mean that the act of hiking and walking within geocaching would have been

considered a core activity (frequent and routine) to 11 participants and a balance activity (nonfrequent or novel) to five participants. The game of geocaching itself would have likely been a balance activity to all but two participants.

4.2. Method

We first conducted written surveys with each participant to gather demographics and obtain background information on how they normally participated in outdoor activities. The survey took about 15 min to complete. Participants then walked around an area adjacent to our university campus and were told that they should separate and collectively try to find two geocaches each within a 1-hr period. The area contained five geocaches that we told participants about within a 1-km (0.6-mile) radius. The area contained a large shopping mall, parking lot, and an urban park with sidewalks and trees; therefore, participants were usually separated by a distance of 100–300 m, although buildings, trees, and other structures visually separated these areas to create the feeling of a more distant connection. Geocaches ranged in size from "micro" (a film canister) to "regular" (a small Tupperware container). They also varied in difficulty. For example, an easy geocache was hidden in a stump underneath some tree bark. A difficult geocache blended into the environment by being hidden behind a false electrical cover on a parking lot post. We provided participants with paper printouts of maps showing the location of each geocache along with the information found on each cache's web page. We did this so that all participants would have access to the same basic cache information regardless of whether they brought additional devices or geocaching apps. We imagined that participants would mutually help each other as they hunted for their own geocaches. We also anticipated they would engage in casual conversation about other activities, their surroundings, and so on. After completing the geocaching activity, participants were *separately* interviewed about their overall thoughts on the experience. We asked them to give us a step-by-step account of the activity, how they made use of the audio and video links, and how they interacted with their partner.

4.3. Data Collection and Analysis

All interviews were audio-recorded, and handwritten notes were kept. We analyzed our interview transcriptions and notes using thematic analysis to understand the main and recurring themes in our data. Here we iteratively reviewed each transcript multiple times and noted what we felt were salient observations and points. We wrote these out on a whiteboard and categorized the different aspects that we saw in the data. This included specific acts and behaviors of our participants where we looked across participants to see if there were commonalities and differences. This analysis revealed themes around the types of specific activities that benefitted from the mobile video connection (navigation vs. searching), the role of video and audio in creating an intimate experience, the ways the mobile video connection caused distraction and safety concerns, the embodiment of the remote person, and privacy

concerns. Next we present our results based on the themes that emerged in our analysis. More results can be found in Procyk, Neustaedter, Pang, Tang, and Judge (2014); our focus here is on the results most pertinent to the design and experience of using mobile video for outdoor leisure activities.

5. SHARED GEOCACHING STUDY RESULTS

Nearly all individuals enjoyed participating in shared geocaching with their partner over distance. Participants expressed the same sentiments that are typical with geocaching: They enjoyed doing a physical activity with someone else, they liked being outdoors, they enjoyed the challenge of searching for geocaches, and they liked the novelty of the technology. Particular aspects of the mobile video link helped to create this experience, and some hindered it. We detail these next along with the ways in which people's experience around shared geocaching manifested with the technology probe.

5.1. Camera Work

Camera work often becomes a challenge when participating in video calls, be it within the home (Ames et al., 2010; Kirk et al., 2010) or while mobile (Jones et al., 2015). Shared geocaching also saw complications around camera work, although the ways in which camera work became a challenge were somewhat different than in other settings, given that the camera was worn by a participant and not held. The challenge was that the technology probe's setup to provide a first-person view of the remote environment meant that the camera work was somewhat automatic—the camera would simply point to wherever the person was looking. Geocaching typically involves two activities: (a) orienting oneself geographically and navigating to a specific area by walking, and (b) performing a fine-grained search within a specific location for a geocache container. When participants were walking to the general area containing their geocache, it was generally easy to see scenery and the location's environment over the video link. This was because the resolution of the video was high enough to see the general environment and the pace of walking made the camera relatively stable. Participants talked about helping one another navigate to the right area if a person wasn't sure. Thus, camera work was straightforward and worked well in these cases.

> [My partner] was able to find her way and I was able to help her by looking at the phone. So I was able to see where she was that way. I could recognize markers outside. So when she was moving her head, looking around, I could see what she was looking at, and I could see a sign for [the store] and I knew exactly where she was and I told her to go right. (P6)

On the other hand, when a person had found the right general space and then started searching to find the geocache container, the wearable camera and the associated

"automated" camera work it created were less useful. The resolution of the streamed video was not high enough to show specific environmental details that might reveal where a geocache container was hidden, and fine-grained searching required viewing the area at certain angles and distances, which was often difficult for participants to frame with the head-mounted camera. The wearability of the camera also meant that it was not possible for the remote person to control what he or she was seeing, and the viewpoint tended to move around quickly as the camera controller looked around the environment.

> I couldn't help [him] find his [geocache] because I had no sense of what he was looking at. He thought he found it … but I think it was a power box the city put there. I looked at his screen to see. I had no sense of orientation. The camera was crooked. The shot was too tight. (P2)

> This way there was a disconnect because you can't be physically right there moving things and helping. And that was frustrating. And what I could see was limited. He was looking down a lot. (P3)

Figure 6 depicts this type of experience (showing a re-creation of the activity). In the left image, the camera faces directly down to see within the tree stump. The right image shows the remote view over the video link, where it is difficult to make out what is shown as well as the context of what is around it. The geocaching container is visible in this location underneath some leaves but difficult to see over the video link (and sometimes even in person, as it is purposely hidden). Figure 7 shows the hidden container—a film canister covered with camouflage tape—after being found.

5.2. Engagement

Video calls in the home have been shown to focus on either conversations or the sharing of activities over longer periods (Judge et al., 2010). This is similar for mobile

FIGURE 6. Looking for a geocache (left) and the remote view from the camera (right).

FIGURE 7. The geocaching container after being found.

video calls when people are out and about (O'Hara et al., 2006). Participants' experiences during shared geocaching migrated between these two aspects—conversations and shared activities—as they walked and geocached, and their specific geocaching activities changed over time (e.g., navigating vs. searching for a container). At times, they would converse about the general activity as well as everyday happenings, and at other times they would shift to be highly focused on finding their geocaches, where there was little talk. Most interesting was the way in which the nature of the activity along with the technology probe setup created a highly intimate connection between partners. When video calling at home, people are in the private confines of their home. Yet when geocaching, people are doing a somewhat private activity in a public setting. Moreover the act is, at times, meant to be secretive, and geocachers do not want nongeocachers to know what they are doing. Because the video and audio links were sharing information privately between partners—bystanders could neither easily see the video screen nor hear the audio from the remote partner—participants felt as though they had an intimate level of connection with their partner and a strong sense that they were participating in an activity with only one other person, as opposed to the larger backdrop of people coming and going around them.

The audio link provided the strongest sense of connection to one's partner because it was continuously going whether or not a person was saying anything. To talk and share conversation, no additional effort was needed; one could simply speak and be heard. Background sounds from the remote location would also transmit, be it sounds of the wind, vehicle traffic, or passersby. Because earbuds were worn, the sounds from one's local environment were somewhat muted in favor of audio from the remote location. This shared a sense of place in a highly nuanced way, despite the auditory mismatch when people had a harder time hearing their local environment.

> He's like the voice inside my head. Because with the earphones on you kinda shut out the other noises around you. It's interesting because I'm hearing what

> he's hearing. It's kinda weird that the stuff I'm hearing might not relate to what I'm seeing. You need to get used to that. (P1)

Video was seen as an extra benefit on top of the audio and added to the sense of an intimate experience by providing remote viewers with the view as seen by their partners —a view one typically does not get. Yet video was more heavyweight to view, as one had to lift their arm to see the video link. In this way, it was a more purposeful gesture. Participants enjoyed the video feed enough that lifting one's arm to view it was not generally seen as being burdensome, however. Participants were drawn into looking at the video, even if there was nothing that they specifically needed to see. Instead, they *wanted* to see it.

The level of connection and focus on one's partner was sometimes so strong that participants became overly focused on their partner rather than their own location and experience. This made them feel close to their remote partner; however, it also detracted from their experience of their own environment. Participants often found it difficult to completely focus on both settings—the connection with their partner and their own surroundings—at the same time. Both required a large degree of effort in order to follow what was happening. Too much focus on a partner's view sometimes led to safety concerns about crossing streets or being in close proximity to cars. It also meant that the enjoyment of one's own location was sometimes diminished. Geocachers often go to new locations to experience them, much the same way that hikers desire to get outdoors and enjoy a scenic environment (Neustaedter et al., 2010; O'Hara, 2008). The technology probe tended to challenge such desires, as it meant that people could focus on their partner's voice or look at the video feed and ignore their surroundings.

> Um … I'd say I might have focused too much on trying to see what he was doing rather than doing what I was doing. I may have ignored some of my surroundings. (P2)

> I could hear her … so I was paying more attention to her than I was to my own task. … I was paying so much attention to the screen that I forgot I was in an area with moving cars. So I had to pay a little attention to … you know, I was in a parking lot with moving vehicles. (P6)

Unlike more typical video calls in the home, geocaching has a targeted goal. In our setup, each participant had their own specific goal of finding their geocache. Sometimes the desire to accomplish one's goal overpowered the need to participate in the activity "together." Here participants sometimes wanted to disengage from their partner to try to find their own geocache container. Thus, in these situations, the connection was "too close" and people wanted to be on their own for a portion of time, such that they could then return to being with their partner after a certain period.

> He kept busy looking at mine though. He kept saying "you're walking the wrong way." I vaguely know where it is so I kept walking and he kept looking at my screen. I found it distracting and told him to mind his own business. (P5)

Although the selectively available video afforded disengagement because people could choose to not look at it if they wanted, the continuously available audio feed did not easily support such disengagement, as one's partner could keep talking and be heard. One could conceivably remove the earbuds to disengage from the audio connection, yet partners did not do this, as there was a sense of obligation that the audio link should remain continuous and be heard. Instead, partners needed to verbally negotiate alone time by talking to each other and explaining that they needed to temporarily focus on finding their geocache container rather than be talking and listening.

5.3. Privacy and Embodiment

Mobile video calls have been shown to be a largely private act, where a person might be having a conversation with another person or showing them something while out and about (O'Hara et al., 2006). In these situations, people often don't want to be overheard and they often don't want others to see the video feed on their mobile device screen because of privacy concerns (O'Hara et al., 2006). Our participants had similar concerns: They did not want to draw people's attention to the fact that they were using mobile video during their activity. Yet the mobile video setup changed the appearance and behavior of our participants as compared to the general public, and this was noticeable and affected their experience. Many participants described getting looks from other people in the general public resulting from wearing the prototype as well as the ongoing conversations that they were having with their partners aloud. Although the remote person's audio was private, one's own voice was not. Here the strong connection and sense of presence that participants were feeling with their partner created benefits and helped to dampen concerns. That is, looks from the general public tended to not bother most people because they felt as though they were not participating in the activity alone. Each could see their partner's situation and comfort the person, if needed. Sometimes just knowing that the other person was "with them" and knew what was happening was comforting enough to not let odd looks bother them.

> … she was walking through the mall and she said people were looking at her, and I was able to look at the screen and see that people were staring at her. (P7)

> Except when I was in the mall. … I felt a bit self conscious. … I felt like everyone was looking at me. I think people thought it was more weird at first because people could hear me talking to somebody, and then they would look up and see the glasses and be like, "Oh, she's doing something strange." Especially when it got dark, because the red light stood out a little bit. (P12)

Because of the looks they were receiving, participants in general wanted the technology setup to be less visibly noticeable to others. They wanted to be able to engage in the shared activity but not make it obvious that they were streaming video to a remote person even though most participants did not feel that there was a problem with streaming video of bystanders and others around them, because it was being streamed and not recorded.

Yet juxtaposed with these findings were issues for participants around embodiment. Some participants wanted a greater sense of embodiment at the remote location such that others around might know that they were "with" their partner in the remote location. The challenge was that remote users were not visible or represented in any strong way. The only indication that a user was connected to a remote person was the visibility of audio earbuds in one's ears and the red "On" light on the wearable camera. Yet these do not necessarily indicate that there is indeed a remote person connecting in. The red light may easily indicate that video is being recorded and not streamed, and headphones might suggest someone is listening to music rather than talking to another person. This weak embodiment meant that sometimes people in the general public (e.g., passersby) would engage with participants in conversation. This engagement made the remote partner feel a strong lack of connection, and the experience suffered as a result.

For example, in one instance a husband and wife were connected and the wife stopped to interact with other people at her location. The husband could hear the conversation and see the people his wife was talking to, but he had no way of interacting with them. Instead, his interactions were solely with his partner. Moreover, other people at the remote location did not even know that he was a part of the activity because he had no live presence or embodiment next to his partner. This "ruined" the experience for him because he no longer felt the close connection with his partner.

> Then I could overhear [my wife] talking to people in the street asking for directions. And I said well wait a minute, I should be helping you because we're supposed to be collaborating. [I felt disconnected] because now [my wife's] talking to other people. And I know what it's like when you're on the phone and you're talking to people next to you and you've got a voice in your ear. (P6)

6. SHARED BICYCLING TECHNOLOGY PROBE

Following our study of shared geocaching, we wanted to see how a similar mobile video conferencing system might be used for a leisure activity that was faster paced with more physical movement and different options for camera placement. We also wanted to compare parallel experiences, where both people are doing the activity together (e.g., shared geocaching), with mixed experiences, where one person watches the activity but does not actively do it. We chose bicycling as an outdoor leisure activity given bicycling's relative ubiquity across many cultures. We hypothesized that an audio connection would provide an enjoyable conversation between bicycle riders, whereas video may be valuable for periodic viewing of the remote location or rider. For example, riders may enjoy

stopping to share a view from a lookout point or of a historic site. We also felt that family members or friends who lived far away might enjoy being taken on "tours" of areas that were less known to them.

Our second technology probe was called *Shared Bicycling*. Again, our goal was to quickly and easily create a technology setup that could allow us to explore the experience of shared bicycling instead of focusing on deeper implementation work. For this reason, we used existing commercial software (Google+ Hangouts) and hardware (Android smartphones and iPod Touch devices). As part of our design efforts, we tested out various configurations and placements of smartphones on a bicycle to understand how they could be used to stream video of the bicycling experience to remote users using

FIGURE 8. The Shared Bicycling technology probe. Top: The bicycle rider with iPod Touch devices attached to the bicycle; bottom left: iPods in bicycle mounts next to mobile hot spot; bottom right: iPods attached to bicycle.

commercial video conferencing connections. Here we compared one versus two camera views and various camera angles. We tried wearable cameras placed on clothing or hats to see if it would create a better viewing experience; however, the stability of these locations was less than desirable (e.g., camera shake was an issue).

Our final prototype used two smartphone bicycle mounts and two smartphones to create both a first-person view and third-person view for remote family or friends. As seen in Figure 8, one smartphone was mounted on the front of the bicycle's handlebars and faced outward to stream the rider's view from the bicycle (first-person view). The camera was angled straight ahead but could be adjusted as desired. The second smartphone was mounted on the handlebars and faced upward toward the rider to stream the rider's facial expression to the remote viewer (third-person view). Again, the camera angle could be adjusted up or down. The smartphones captured and transmitted audio to the remote person so the users could talk to each other throughout the experience. Users had a standard earphone bud to support shared audio; we note that in some jurisdictions in Canada and the United States, wearing earphones in both ears is illegal. In our region of study, it is legal to wear earbuds while bicycling, though only one earbud is recommended for safety reasons.

We used Google+ Hangouts to stream video and audio between the smartphones because it allowed us to easily share multiple video connections. A mobile hotspot (placed in the rider's pocket) was used to provide a 4G/LTE cellular Internet connection. We created two types of shared bicycling experiences so that we could compare the experience in different situations. In the parallel experience, we used a four-way video call (two smartphones on each bike) to connect two users when each was riding a bicycle at the same time. Figure 9 depicts the four-way call showing a remote cyclist's first-person view (left) and the third-person view of the remote bicycle riders (right; video chat window includes an additional video feed, in black, from an experimenter's device for testing purposes). Users could click on a video window to change which camera view

FIGURE 9. The remote view as seen on the smartphone: Left is a first-person view of the environment, and right is a third-person view of the remote bicyclist.

dominated the screen. This way they could toggle between the remote rider's first-person or third-person views, as desired.

In the mixed experience, one bicycle rider shared his or her camera views with a stationary user at a computer. Here only a three-way video call was required because stationary users had only one camera. Both the bicycle's first- and third-person views were simultaneously broadcast to the stationary user. The computer view looked similar to the view on the bicycle's smartphone, only it covered a larger laptop display. On the bicycle, the computer user's view stayed in focus and filled the screen for the entire ride because one camera was streaming video. A video depicting the Shared Bicycling technology probe can be found in Chua, Forghani, and Neustaedter (2017).

7. SHARED BICYCLING STUDY DESIGN

We conducted an exploratory qualitative study with the goal of understanding how our shared bicycling technology probe would be used, what challenges would emerge, and what design factors would lead to feelings of connection and disconnection. Half of the participants used the technology probe as a parallel experience, where both went bicycle riding at the same time, and the other half had a mixed experience, where one person rode a bicycle and another watched from a computer.

7.1. Participants and Recruitment

We recruited 28 people (11 women) for our study—14 pairs of friends or family members—via advertisements on social media and within our university community. Two participants were between 40 and 50 years of age, and the rest were between 18 and 30; thus, our participants generally represented a young demographic. Two stationary participants were from another country, and the rest resided within Greater Vancouver, Canada. All participants except three had previously ridden a bicycle; the three remaining participants acted as stationary observers during the study. Thus, the activity was likely considered a core activity for all but three participants, although this could vary depending on how often each person rode bicycles. All active participants had gone bicycling with friends or family before, but none had used a video communication system while on a bicycle. All participants had experience using video communication systems on mobile devices. Four pairs were in a romantic relationship, two were siblings, one was parent–child, two were coworkers, and the remaining five pairs were friends. We had seven male–female pairs, five male–male pairs, and two female–female pairs; this becomes relevant when we describe results related to camera viewing angles.

7.2. Method

Participants completed either a parallel or mixed bicycling experience based on their own interest. Seven pairs participated in each setup. In the parallel experience, each pair started at a common location where we set up the technology probe on either their own bicycle or our study bicycle. Participants then rode along two routes to create the feel of being in different locations from their partners. For the mixed experience, one participant rode the bicycle while the other, a stationary partner, was located at our university campus, his or her home, or a coffee shop, depending on convenience for the participants. All used a laptop or tablet to connect to the remote bicyclist.

Bicycling Routes

Participants were able to select their own bicycling duration within a 30- to 60-min time limit. We selected this period because we wanted riders to move beyond an initial novelty period to a point where they were focused on bicycling with their partner rather than the novel technology setup. Our pilot rides found this to occur at around the 15-min mark. We advised participants to pick scenic routes (e.g., with interesting views or shops) so that they might be encouraged to use the cameras to show their surroundings to their partners. We suggested routes less than roughly 10 k (6.2 miles) to fit the timing of the study. Most participants ended up asking us for suggestions on general areas for their bicycle ride.

Participants selected bicycle routes ranging from 5 to 9 k in length. Six pairs rode along a trail near a city dyke next to the ocean and a small village area containing shops and restaurants. This area had less traffic and several historic sites (e.g., ships). Three pairs chose portions of a large trail circling the city's largest park, Stanley Park. This location had views of the ocean and harbor as well as many forested areas, yet it is often very populated with other bicyclists, joggers, or walkers. Four pairs chose an area near our university campus because of its convenience. This area includes parks, schools, and bicycle lanes but is less bike friendly because of a large number of vehicles. The remaining pair chose a local park that contained pathways and scenic views. Some routes ended up having slight inclines, which made them more strenuous. All participants chose the specifics of their route as they went. Thus, they started in a general area and routes deviated as they rode.

Alternatively, we could have selected very carefully controlled routes and had partners ride by specific locations of interest. However, we felt this might overly restrict the participants and make them more focused on following the instructed route rather than on the shared activity and their partner. This would have created a different type of shared experience, though we encourage future studies to investigate this area. We also note that the bicycling activity was somewhat different than geocaching in the previous study. Unlike geocaching, which includes a structured task and goal (finding the geocache), bicycling is much more open-ended and less goal driven, aside from the goal of traveling between two locations.

Technology Probe Usage

We met participants at the starting point of their route and set up the technology probe. Participants were told they could remove or adjust the devices, switch between the video links, and stop at any point during their ride if they wanted to share scenery or talk while not bicycling. In the mixed experience, the stationary participants could choose which video link to look at; all camera views were shown with thumbnails, and the main view (shown across the majority of the screen) would change to the selected video. In parallel experiences, we imagined that participants would utilize both cameras and mutually show their surroundings. In contrast, we anticipated that in mixed experiences, only the cyclists would be showing key points along the route. For both, we anticipated that participants would engage in casual conversation about other activities beyond the bicycle ride.

Semistructured Interviews

After the bicycle ride, we interviewed each participant individually to explore his or her experience. We purposely did not interview participants together, as we wanted to hear the views of each participant without the potential for social pressures that might cause one to conform to his or her partner's view. Interviews lasted up to 20 min. Interviews with three stationary participants who were remote to us were conducted over Skype.

Interview questions focused on when and why participants used the video or audio links; what they looked at or showed via the video link; what they talked about over the audio link; what aspects of the experience made them feel engaged or disengaged from the remote partner; potential safety concerns; and privacy issues, if any. We asked them to share stories about the experience in order to describe it in as much detail as possible. Here we probed for critical incidents that created positive or negative experiences. At the end of the study, each participant received a $20 payment.

7.3. Data Collection and Analysis

All interviews were audio-recorded, and handwritten notes were kept. We fully transcribed all interviews and then used thematic analysis to code and understand the main and recurring themes in our data. Our analysis process was similar to the previous study; we iteratively reviewed our notes, wrote observations on a whiteboard, and categorized the details of the behaviors and experiences that were reported to us by participants. We looked at individual participant experiences and compared across participants. Our analysis revealed key themes around the ways in which video and audio supported or did not support connection and engagement during the bicycle ride, privacy issues generated as a result of the audio and camera views, and instances where privacy was not a concern. We explore these results next. We provide anonymous participant quotes, where we list if they were in the parallel or mixed setup.

8. SHARED BICYCLING STUDY RESULTS

Nearly all participants expressed interest in the novelty of the technology probe and enjoyed bicycling with a partner for both parallel and mixed experiences. All participants used the video, audio, or both to communicate with their partners throughout the duration of the bicycle ride, though the amount they used it varied. In the following sections, we explore the nuances of participants' bicycle rides and uses of the technology probe.

8.1. Camera Work

Like shared geocaching, the camera work involved in positioning cameras and aiming them at interesting things is largely taken care of by the technology: The first-person camera faces outward from the bicycle mount on the handlebars, and the third-person view faces toward the rider's face, again from a bicycle mount. Yet we found camera work manifested in unique ways because of the activity, the technology probe setup, and the ways in which people found value in the different camera views. Most participants in both the parallel and mixed experiences said that the third-person view showing the bicyclist was most important to feel connected, because they were able to see the person's facial expressions and reactions to conversation or their bicycle ride over the video link. This view was valued more than seeing the scenery and the participants' view. It also reflects the reasons why many people say that they like to use video chat systems: to see their loved ones and their facial expressions (Ames et al., 2010; Judge & Neustaedter, 2010; Kirk et al., 2010). One participant even felt that the setup was more intimate compared to bicycling alongside the partner in person because it was like having a face-to-face conversation—again, reflecting more typical uses and expectations around video chat.

> I wanted to see his reactions to what I was saying. (P12, Mixed)

> I liked that I can easily see the see her reaction to what I'm saying. I usually go biking with her, but when we do go biking, we're more focused on the road rather than looking at each others's faces. (P16, Parallel)

Because it was sometimes difficult to switch video views while bicycling—looking down at the smartphone display long enough to find and touch a video view—participants tended to leave their view on the third-person camera so they could see their partner's face when they would glance down at the smartphone. Here we see that camera work manifests itself in a new way compared to mobile video calls because participants have the option of seeing different views. Thus, even though the act of positioning cameras is "taken care of" by the bicycle, the new ability to see different viewpoints creates added work. This was added work for the recipient of the video, though, and not the sender. This contrasts video calls in home settings, where the sender of the video is responsible for the camera work (Ames et al., 2010; Kirk et al., 2010).

There was also hesitation around switching views because of the lack of value that people saw in the first-person view given the way it was set up and presented to them. Parallel participants commented that seeing the landscape and scenery on the small smartphone display was challenging and did not add a great deal of value beyond seeing their own scenery around them. The remote view was not a lot different than what they were already seeing. Thus, the benefit they gained by switching to see the remote location was not worth the effort required to do so. On the other hand, seeing the facial expressions with the third-person view was fairly easy, despite the small screen size. Landscape and scenery views tended to contain a lot of detail, which can be hard to see on a small display, whereas faces were not as detailed and easier to recognize and see.

That said, the first-person view of the remote surroundings did become important in situations when a participant became lost and needed navigational help from his or her partner or in moments when one partner wanted to show the other person something specific. In these situations the need for a first-person view outweighed the limitations of the small screen and the effort required to switch views. Participants described showing interesting sites near them and other people of interest, for example, people staring at them, people wearing funny clothes, a wedding in the park. One participant even saw some of their friends while bicycling and showed them on the camera. This process worked well if the action or location would take time to show, but people were less apt to stop and show something if it was easily passed by. For example, one participant said he would stop to show a plane taking off at the airport because it was a long event, yet he would not want to stop to show a particular house on the side of the road, which could be done quickly. Thus, the effort of showing things needed to reflect the novelty and duration of what was being shown.

In the mixed setup, because stationary participants were not bicycling and viewing video at the same time, they found it easier to make use of both video feeds because they could easily perform the camera work involved in switching views—they were not simultaneously riding a bicycle. Stationary participants wanted to see where their partners were and their reactions to what they were saying. Thus, stationary participants enjoyed and utilized both video feeds. They liked seeing the bicyclist's point of view and found it engaging to be able to visualize what their partners were seeing instead of only having the sights described verbally.

> We were talking about different stuff because we were catching up lately so I was explaining to him things around here. Not just the things that he was seeing in the video. It's like we were walking and talking. As if he were having an idea of where I'm riding my cycle but as a whole he was thinking of how my life is going here. (P14, Mixed)

The most rewarding and valued mixed experience occurred when the stationary participant was not familiar with the bicyclist's location. For example, one pair of participants were long-distance siblings who had not talked in months. One was local to our study and rode the bicycle to show her remote brother what the city was like. This sibling lived in Germany and had never been to Vancouver. The stationary user

utilized both camera views quite heavily during the study so that the local participant could tour the remote sibling around the area. Here she shared views of the harbor, local restaurants, and statues.

> The best part was I've never seen Canada, so that's like, yeah. The moment we [were riding] it was quite amazing because it's just someone taking you on a bike ride, and having to see the place around is quite nice. Because if you happen to use Google Maps and go into street views you can see quite a couple of things there, but you can't see moving video. If you know what I'm trying to say. (P28, Mixed)

Camera work also involved one's ability to time and look at the video displays in a safe way. Unlike more typical video conferencing, either in home settings or while mobile, the bicyclists did not have the luxury to look at the video feed at any point, or linger on it for long periods. Naturally, they had to pay particular attention to their bicycling activities and where they were going. Participants generally felt safe in using a video feed while bicycle riding, but it was not before developing careful strategies around when and how to look at the video feed. Bicycling participants used audio throughout the ride to communicate with their partner, and video was used during times that they deemed were more appropriate, that is, when streets were not busy, when there were fewer people around. When looking, they recognized the need to glance rather than stay focused on the video feed. Thus, unlike in-home video calls, when people often feel obligated to stay looking at the remote person's video (Ames et al., 2010; Kirk et al., 2010), the bicyclists set aside this "norm" because they understood the safety risk if they looked at the video feed for too long.

> This kind and normal bike riding are pretty much the same. I just have to be more attentive, I guess, so I don't hit somebody because I'm looking at the video and talking at same time. (P9, Mixed)

> When I first biked, I kept looking at his face, so I wasn't paying attention to the road and the people around, and I kept almost hitting everyone. But then I realized not to keep on looking at that, so after the first 5 minutes I just stopped looking at his face. … Once I reached Holland Park, the concern wasn't really there because it was a lot safer than the roads with so many people driving around. (P19, Parallel)

Even so, some participants found it challenging to set aside their preconceived notions of what video chat entailed—the idea that people should be looking at each other during a video call. This created tensions for some people because it was hard to do so safely.

> I'd rather much like look at him while he's talking and vice versa. If it was a phone call, it might be different because I know that I'm not supposed to be seeing anything, whereas in a video call, I feel like I'm supposed to look [at his face] because I'm supposed to be talking to him face-to-face. (P17, Parallel)

8.2. Engagement

Similar to shared geocaching, we found that people had a strong sense that they were participating in an intimate experience with their remote partner. That is, even though they were participating in the activity in a public space and with many otherswho were around, the activity and their engagement was heavily focused on their partner as opposed to everything else that was going on around them. A sense of close connection was created because they were sharing in the activity at the same time and could continuously talk with one another. This was even the case for the mixed setup, where several participants said that they felt they were biking alongside their partners despite being stationary somewhere else. Even though bicycle riders in both the mixed and parallel setup viewed the video links selectively, the fact that they could view the video link at any point in time meant that they had a connection into the remote location. Thus, it was the *ability* to see rather than the *act* of seeing that made video a powerful connector.

> So, even though I didn't really look at him that much … being able to see if I wanted to was the best part. (P22, Mixed)

> The fact that we were both biking and both doing the same activity. In general, it really felt like we were on the same page and we were having similar problems as well. I think that made us feel very relatable to each other. I did feel that being able to hear him as if he was beside me sometimes made it feel a lot more realistic. I think that was something to add on, as well. (P17, Parallel)

> The experience was interesting. We've obviously never done anything like this before. The best part would probably be, kind of like being together but not really together, so we're not in each other's face but still kind of connected. (P12, Mixed)

Unlike shared geocaching, we found that the engagement with one's partner was continuous and lasted throughout the study. Participants were not interrupted by others around them, they did not stop to talk with bystanders, and they did not feel the need for individual time away from their partner (all findings from shared geocaching). Instead, they stayed engaged in the activity solely with their partner. The speed of the activity and the continuous movement of the bicycle meant that it was much more difficult to be engaged with the others around.

Almost all pairs talked to each other throughout the entire bicycle ride. Participants in the mixed setup utilized both audio and video heavily, whereas participants in the parallel setup primarily used the audio link to feel connected. The video link was seen as being secondary in importance to them. Conversations tended to be about the same things that a pair said they would normally talk about over the phone or when in person. This included their day-to-day activities, relationships, work or school, and so on. Thus, conversation was much less about the activity of shared bicycling and more about life in general. That is, participants tended to stay with the familiar—what they might normally talk about over video chat—rather than create new kinds of conversations that might focus around the novelty of the activity itself, the act of bicycling, or what they were seeing around them.

Compared to the parallel experience, pairs in the mixed setup talked more about their surroundings because the stationary participant was able to concentrate more on the video feeds and ask questions about the surroundings. This was particularly important for those who were unfamiliar with the remote location. Bicycling is not always an easy activity and, for some people, its strenuous nature affected engagement with one's partner. Some participants were not used to bicycling and felt that having to bicycle while using the technology probe was tiring. Not all had chosen bicycling routes that were easy to do, and some involved steep inclines. Other participants were not used to bicycling regularly. Thus, the physicality of the activity made it difficult to stay engaged with a remote partner because they had to focus more on bicycling than conversing or glancing at the partner's view. Participants said that conversations were sometimes not very "deep" because they were talking and concentrating on bicycling at the same time.

> We talked about school, what I did the previous days, what I want to eat later. Normal everyday things we'd talk about while, maybe, walking around or doing other things. There weren't deep intimate talks. I guess when you're biking, you can't really engage in those types of conversations. (P11, Mixed)

> Riding the bike was kind of exhausting and at some point I didn't really want to talk. I was going uphill for quite a bit in Garry Point so it was hard to keep a conversation going while going uphill. (P19, Parallel)

The more experienced bicyclers found that the activity was similar to regular bicycling with friends or family. They set a pace that allowed them to bicycle while conversing. Thus, the nature of the shared bicycling experience will depend on whether it is considered a core or balance activity for people and whether the route a person selects matches their bicycling abilities.

Over time, the novelty of the technology wore off for some participants, and they felt that the experience was "dragging" and "boring." This was an issue brought up in both parallel and mixed experiences, yet it prominently surfaced for stationary partners in the mixed experience. They sometimes felt the need to force a conversation with their remote partner because they had nothing else to do except engage with them. At times they felt left out of the activity or that the bicycle ride's duration was too long. The challenge with going for a bicycle ride is that, once one has started riding, the activity continues until the destination is reached. This contrasts more typical video calls from home settings where a person might be more able to end a call at a point where conversation lulls or one becomes less interested in talking.

> I got kind of bored after some time. If I were on the bike, it'll be a better experience for the both of us. (P12, Mixed)

> I was really bored. I'm like, "I have nothing to do here." Watching someone else bike, I was like, "Oh, I should be biking or something like that." (P25, Mixed)

8.3. Privacy Concerns

The nature of bicycling is such that people are moving at a faster speed than walking, where they feel and hear the wind blowing around them, and they are sometimes in an area with vehicle traffic that might contain more noise. This was the case for our participants, where the environment and act of bicycling created privacy challenges for them. Participants tended to have to talk louder to their remote partner so they could hear them over other environmental sounds, as well as any wind blowing across their microphone. This meant they tended to talk more loudly than if they had been simply walking. They also recognized that they were participating in the activity in a public place with many others around. This was because the areas in which they bicycled tended to be more populous than the areas in which people geocached during our other study. Several participants commented that their conversations tended to be filtered because of these reasons, even though they were moving at a pace where people might hear them only for a few seconds. As a result, they would try to talk about things that they were okay for surrounding people to hear. This does, however, reflect a different situation than in-home video calls, where a person is in the private confines of his or her home.

> It was fine because we didn't talk about anything that serious. We understand that the environment was very open, public, so it wasn't like when we're talking at home. (P1, Parallel)

> I did choose my words wisely because I was speaking pretty loud, so I tried not to swear and stuff and be aware of the people around me. (P19, Parallel)

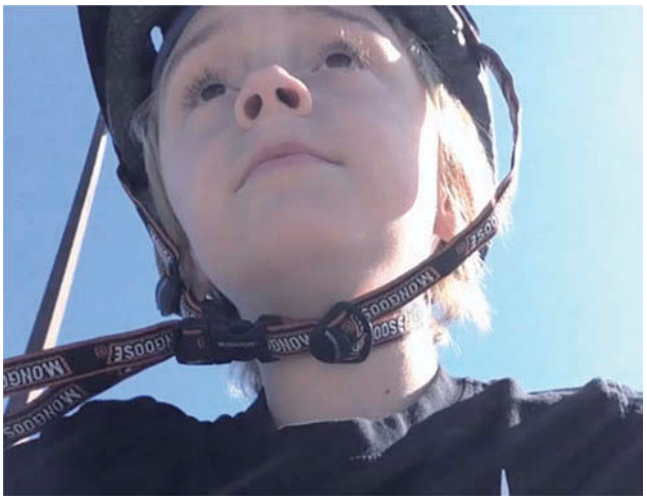
Even still, participants drew attention from those around them where they talked about receiving glances and looks from bystanders that were of a quizzical fashion—or, in some cases, stares. Participants felt that the visibility of the smartphones, bicycle mounts, and earphones helped to visually explain the situation to bystanders in hopes that the bystanders would recognize that the bicyclist was in a call and not talking to themselves. Thus, the increased visibility of the technology setup aided any social awkwardness rather than further exacerbating it.

> I'm a fairly loud person to begin with so a lot of people were, like, looking over, looking around, wondering who that guy was talking to. I guess they were kind of confused, but I didn't mind that. I did like seeing their reactions. (P17, Parallel)

> I wasn't really concerned [about privacy] because I had headphones in, so, I guess, people around me automatically assumed I was talking to someone, but even with that, I'm still an open person so I didn't really care if people thought I was talking to myself. (P11, Mixed)

> They were looking, but I think they realized that I was talking with someone … when they saw the earphones. (P12, Mixed)

FIGURE 10. An example of an awkward camera view.



The setup of the technology probe also created privacy challenges for participants given the pragmatics of the positioning and mounting of the camera. Bicycle handlebars are positioned below one's head, and so the third-person camera view looked up at the bicyclists. This meant that the camera would sometimes show unflattering views of participants that they were not used to providing others. For example, it might show a view "up their nose" (Figure 10 shows an example) or a close-up view of one's chest or neck. Participants generally felt that such views were too intimate. Unlike more typical video chat calls in home settings or while mobile, one's camera feed while bicycle riding is not easily in their control because of the affordances of the bicycle and mounting options. Such camera placement led to feelings of awkwardness between some partners from the side of the person viewing the camera feed.

> I was looking mostly at her point of view rather than her face, because [the camera] wasn't pointed at her face mostly—it was pointed at her chest area, and I was like, "uh, I don't want to look!" (P25, Mixed)

Curiously, the people providing the camera view did not comment that it was a problem. Instead, the view was just something that came along with the fact that they were video calling while bicycle riding.

Situations like this tended to be less socially awkward for those who shared a close relationship. For example, one participant did not mind the awkward angles at all because he knew his partner well and both were very used to video communication technologies.

9. DISCUSSION

We now turn to a discussion of our results. First, we provide a comparison between the contexts we studied and video chat in the home and while mobile. This provides an understanding of how outdoor leisure activities will likely be experienced depending on their attributes (e.g., location, speed of movement, type of activity). Second, we describe how mobile video streaming creates a new set of design opportunities and challenges that should be considered by designers of video communication technologies as people move to the outdoors to share leisure activities with family members and friends over distance.

9.1. Comparing Contexts

First, we found that our technology probes were especially beneficial for creating an intimate shared experience with one's remote partner. This varied depending on the activity and context, however, which speaks to the way mobile video chat might be used more broadly and designed for across outdoor leisure activities. With shared geocaching, the intimate experience came and went periodically; it was not continuous. This was largely because the activity had different types of events happening within it—walking, navigating, searching, and so on. Sometimes people wanted to be "doing their own thing" and other times they highly valued "being together." There were also interactions with bystanders in the environment, given the pace of walking and searching, an activity that can see slow movement through a location. Contrasting this with bicycling, we see a much faster activity that covers larger distances in a shorter period. Moments and interactions with places can be fleeting. This means that it is more difficult to engage with others around oneself, and it was easier to create a continuous intimate experience with one's partner without interruption. Bicycling also does not have specific goals, as was the case for geocaching. Together, this meant that participants stayed focused on their partners throughout the entire experience, despite sometimes being bored. We return to this challenge later. The act of being continuously focused on one's partner is similar to past studies of technologies such as Jogging Over Distance (Mueller et al., 2007; Mueller et al., 2010); again, the activity here involved only a single event within it, jogging.

Camera work has received a great deal of attention when it comes to video chat in the home as well as during situations involving mobile video calls (e.g., Inkpen et al., 2013; Jones et al., 2015; O'Hara et al., 2006)). In the home, people work hard to stay on camera, show children's activities, tour locations, and so on. While mobile, people face challenges in holding a mobile device and creating a good view for the remote user as the "video handler" (Jones et al., 2015; Massimi & Neustaedter, 2014; O'Hara et al., 2006). For shared leisure activities, we found camera work manifested itself differently because it did not rely on the work of a video handler per se. That is, a person did not have to hold a camera and orient it for the remote viewer. Instead, camera views were automated based on a person's head movement (shared geocaching) or the movement of the bicycle (shared bicycling). This meant that camera work switched from the local handler to the remote user. This person now had to decide when to look at the video feeds; for how

long; and, in the case of bicycling, which camera to view. This differs from other shared outdoor activity systems like Jogging Over Distance, where only audio is shared (Mueller et al., 2007; Mueller et al., 2010); with video, one must actively look at a display. Remote users found video feeds sufficient, though there were challenges around the size of the displays for viewing landscape and camera movement and a lack of context during fine-grained activities like searching for a geocache container. The former problem is similar to camera zooming and framing issues with Experiences2Go (Inkpen et al., 2013). These challenges meant that people tended to rely heavily on audio to create a shared experience. Display sizes and their availability also created tensions around the embodiment of the remote users. Here people had juxtaposed needs: They wanted to have a visible presence in the remote location so that other local users would know they were "with" their partner, yet they also wanted video technologies that were less visible and less prone to attracting people's attention. Embodiment challenges have been found for other mobile video chat situations where people in the environment do not realize a person is streaming video to a remote user (Inkpen et al., 2013; Singhal et al., 2016).

Our results also point to nuances around conversation during shared outdoor leisure activities. We had anticipated that participants would engage in discussions about everyday life while talking about what they saw around them, similar to past research (Inkpen et al., 2013). In contrast, for shared bicycling, conversations focused very heavily around everyday life and *not* their surroundings. Sometimes they moved to discussions about one's surroundings, but this mostly occurred only in mixed setups (one person watching from home) because the remote user was heavily focused on seeing both camera views. These results suggest that the shared activity may not guide the conversation during activities that do not really require collaboration or help from the remote person. Instead, the shared activity is the catalyst for conversations about everyday life where it creates the "forum" for conversation and dedicates partners to it. With shared geocaching it was somewhat different. Conversations were about *both* the activity of geocaching itself—as participants could collaborate and help each other—and happenings in everyday life. This was similar to past research on watching activities from remote locations (e.g., viewing a child's sports practice; Inkpen et al., 2013); the only difference was that, in the related work, conversations involved explaining what both parties were doing as part of the activity. Based on our results, we see that leisure activities that are goals tructured or present the possibility that partners are able to actively collaborate over distance can create a different type of conversation than activities that are more open-ended. The physical nature of the activity will affect this, though. The challenge (and benefit) with shared leisure activities is that sometimes activities can be strenuous. This occurred for shared bicycling with partners who were less used to the act of bicycle riding or had picked challenging routes. We saw this result in conversations that were considered to be superficial and not very deep. People tended to talk about "the ordinary"—the everyday mundane happenings in their life—first because they wanted to but also because they didn't feel that they could get into a deep conversation with their partner. The difficulty is, sometimes people may not know what to talk about and conversation can feel constrained. Similar findings have been reported in studies of mobile video messaging, where people struggled to know what to share throughout their day because everything seems "ordinary" (Rintel, Harper, & O'Hara, 2016).

This brings us to challenges around obligation and staying connected with a remote partner. When participating in a shared leisure activity, regardless of whether it is goal oriented or open-ended, there is a feeling that one must stay with their partner and continue to engage with them throughout the experience. This occurred for both mixed and even parallel activities sometimes. Certainly our participants were in a study and felt compelled to continue to engage with their partner for this reason, yet they also talked about a feeling to stay engaged because of the leisure activity itself. This helped to create a sense of intimacy and connection; however, it also sometimes created a feeling of overconnection. Generally speaking, video calls in the home do not tend to have such an activity occurring where one might feel compelled to stay in the call because of the activity. Instead, entering or leaving a call tends to be more fluid. Shared activities create a more explicit tie to the video call. We found in our studies that selectively available video worked well at providing a way for people to disengage from their remote partner, whereas continuously available audio was more challenging. It is intriguing that selectively available video requires somewhat heavyweight actions to engage. In our case, it meant lifting one's arm to look at the video feed for shared geocaching, or carefully considering when to look at the video display for shared bicycling. Despite this extra work, people tended to prefer it because it meant that they were more in control of their experience.

These ideas are bound up in notions of privacy and one's ability to exercise autonomy and control over their engagement in a video-mediated space (Bellotti, 1998; Boyle, Neustaedter, & Greenberg, 2009). Generally speaking, participants did not report concerns about streaming video of bystanders while they rode their bicycles or participated in shared geocaching. Simple design elements such as earphones made it so our participants felt that others around them knew they were in a call, yet the fact that it was a *video* call may have been less clear; this is similar to research on video streaming in public settings (Singhal et al., 2016). Unlike video calls in the home, which may be more or less private at least to the family and any household members, calls during shared outdoor activities are in a public setting and susceptible to being heard by others. This is not much different than normal phone calls, but because participants are engaged in an activity and highly focused on their partner, they may more easily forget that what they are saying could be heard by others. Fast-paced activities can also mean that people speak louder to overcome environmental noises (e.g., cars, the wind). This can increase privacy risk for conversations. Our results also point to more pragmatic concerns around camera angles and somewhat unflattering views of people doing leisure activities. Leisure activities are meant to be physically challenging at times, and one's appearance is likely going to be a general issue when streaming video of users when the potential for disheveled hair and perspiration exist, for example. This contrasts with results from other mobile video activities reported in the prior literature where people were video streaming *others* who were participating in a physical activity and not themselves (Inkpen et al., 2013). Unflattering camera views may not bother some people; however, the existing literature suggests that there is at least some portion of the population (e.g., teenagers, some adults) that would be concerned about being seen in this state (Brubaker et al., 2012; Buhler et al., 2013).

9.2. Design Implications and Opportunities

We now describe the design implications and opportunities that our research raises. First, designers should *consider when and how camera views are presented*. For example, researchers and designers should think about what types of camera views to provide, how prominent the video display is (e.g., size, location) in terms of what it needs to display (e.g., people's faces vs. landscape and scenery), when the display should become active and visible for safety reasons, and how privacy concerns around camera angles and loud voices/audio should be addressed. These design factors depend on the specific activity being undertaken. For example, activities involving the sharing of specific environmental details (e.g., specific geocache hiding locations, landscape, and scenery views) should consider high-resolution cameras and displays, whereas activities focused on showing people's faces and facial expressions may be sufficient with lower resolution video feeds and displays. For safety reasons, video feeds could be controlled to only be shown at times of reduced activity (e.g., stopping to look at a scenic view). Cameras should also be placed at locations that do not create unflattering views (e.g., looking up a user's nose).

Second, designers should consider ways to *support varying styles of engagement, activity coupling, and transitioning between such styles*. Similar ideas have been brought up in research on collaboration in work contexts where users transition between loosely and tightly coupled work (e.g., Tang, Tory, Po, Neumann, & Carpendale, 2006), but it is typically not a concern for video calls in the home because people often focus on simply having a conversation. Rather than designing to always show a video link (e.g., a heads-up video display shown on glasses), designs would be better suited to provide users with a video view that they can choose to look at when desired or needed. This could be done similarly to our design with a display attached to a wrist or mounted to a bicycle in a viewing location *out* of one's line of sight, rather than directly in it. Of course, locations and objects might need to be changed depending on the nature of the activity being designed for. We also saw challenges with continuous audio because it was difficult to transition out of working closely with a partner. Designers should explore ways of allowing users to easily turn an audio feed on and off. In the simplest case, this could be done, for example, by using a toggle switch on a device, though it may be more apt to embed such functionality within items that can be worn, such as a shirt or gloves. Such articles might vary depending on the specific activity and what is naturally worn while engaging in it. Designers could also consider more automated forms of control over audio streaming based on the nature of the activity. For example, if a person's location is not changing rapidly and they are geocaching, it might suggest that they are performing fine-grained searching and want to focus on their own task. In this case, it may be okay to turn off audio. Of course, such solutions would need to very carefully consider the chance that automation algorithms are wrong and allow users to override them or turn them off as needed. For this reason, alternative solutions that provide varying levels of audio might be more appropriate. For example, if a system feels that audio may not be needed, the volume level could slowly go down, such that the user recognizes this is happening. Speaking more loudly into a microphone could raise the volume again.

Third, designers should consider ways to better *support remote camera work during shared leisure activities*. Automating cameras based on user or bicycle movement created new types of camera work for the remote user who was now in control of deciding when to look at the video, when to select different feeds, and so on. As far as we know, little research has explored design solutions for easing the burden of remote camera work from the perspective of the viewer. Like other previously proposed design solutions, designs should consider selectively available video feeds. In this case, video feeds may be turned on or off depending on the nature of the activity and whether it would be a "good" time to show video. For example, for an activity like bicycling, it would be important to turn off video feeds when a bicyclist is moving quickly. This could be detected easily with sensors embedded in a smartphone or on the bicycle. Designs could also select which video feed to show users. Views of people's faces were especially valued and should be shown prominently during most activities. However, users should be able to easily switch to first-person views as the nature of the activity changes. For example, if a person slows down or stops the activity, a system could provide that person with a lightweight means to see views of the environment and scenery. Such processes could also be automated to show both the scenery and the remote person's face when users slow down in the activity.

Fourth, designers should consider ways to *allow people to change the degree to which they are represented and embodied in the remote space*. People wanted a setup that was difficult for bystanders to notice while also wanting the remote user to be more "visible" locally with a greater form of embodiments. This suggests designs that are obscure at times so as not to draw attention to the fact that a video call is occurring yet coupled with the ability to become more visible to show local people that there is a remote caller participating in the activity, and perhaps even allowing the remote caller to interact with local bystanders. Design solutions from other contexts might suffice in this case. For example, we have seen mobile video designs for "human proxies" who attend classes on behalf of students and stream content to them (Ishak, Neustaedter, Hawkins, Procyk, & Massimi, 2016). Here displays showing the remote user's video feed are visibly attached to clothing items for the general public to see. Ideas such as this could be extended to shared outdoor activities. Users could choose when and how large they appear on the video display depending on their desired level of engagement and privacy. Video displays could also be selected such that their size is easily visible by others or not, depending on the need for privacy.

10. CONCLUSION

We studied two shared outdoor leisure activities—shared geocaching and shared bicycling—that relied on video and audio streaming to connect remote partners. Participants performed shared geocaching as a parallel situation where both people performed the activity in different locations. Shared bicycling was done either as a parallel experience, with two people riding bicycles, or as a mixed experience, where one person watched another bicycle ride from his or her home. Our findings raise important considerations for the design of outdoor shared experiences over distance, including new ways of thinking about and engaging in camera work; the benefits of intimate experiences through

selectively available video and continuously available audio; new forms of social challenges, such as obligation, as a result of an ongoing leisure activity and varying levels of connectivity; and new privacy challenges that emerge from different types of camera views, as well as environmental factors. Future work should continue to explore additional shared outdoor leisure activities, where we hope our insights and findings can suggest design direction for such explorations.

NOTES

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