"MyEyes": The Design and Evaluation of First Person View Video Streaming for Long-Distance Couples

Rui Pan, Samarth Singhal, Bernhard E. Riecke, Emily Cramer and Carman Neustaedter
School of Interactive Arts and Technology, Simon Fraser University
102 – 13450 102nd Avenue, Surrey, BC, Canada, V3T 0A3
[ruip, samarths, ber1, ecramer, carman]@sfu.ca

ABSTRACT
Couples in Long Distance Relationships (LDRs) often rely on the use of video chat systems to help maintain their relationship. However, designs are typically limited to only supporting face-to-face conversations or providing narrow fields of view. We designed and evaluated *MyEyes*, a First Person View (FPV) video streaming technology probe made with cardboard goggles and a smartphone. Distance-separated partners see each other's view on their screen where it can overlap their own view (Overlapped), be placed above it (Horizontal), or presented at the same time where each is seen with a different eye (Split). We compared the three different views with couples to explore the effect on social presence and body ownership. The Overlapped View was most preferred by couples and it provided the strongest feeling of co-presence, whereas a Horizontal View provided the greatest sense of mutual understanding. Our qualitative results showed couples valued performing synchronized acts together and doing activities 'in' the remote location.

Author Keywords
Long distance relationships; computer mediated communications; first person views; video chat systems; social presence

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous;

INTRODUCTION
Long Distance Relationships (LDRs) involve couples who are geographically separated. LDRs are increasingly common due to various reasons such as school, work and travel [22,29]. Just like collocated couples, relationship maintenance is an important part of LDRs [30]. This includes being with one's partner, communicating with them, and empathizing [30]. Of course, this is hard to achieve when people are separated by distance; thus, many couples in LDRs rely on technologies such as video chat for mediating closeness [25]. The face-to-face metaphor offered in traditional video chat systems such as Skype and FaceTime allows people to see each other's face and to chat as though they are talking in-person [13,24,25]. Some couples also like to share activities together over video chat (e.g., eating, watching movies, parallel working) [25]. Yet this can be limiting since partners lack mobility in the remote space and are not able to touch one another [25]. Based on these limitations, our goal was to explore the design of richer video communication mediums that might allow LDR couples to more deeply immerse themselves in their partners' remote location.

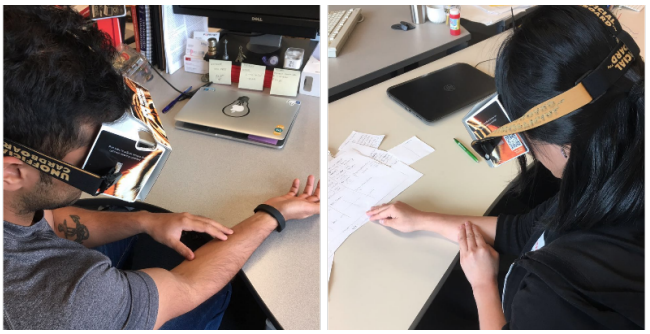

Figure 1. A couple uses *MyEyes* to share their first person views between two locations.

First person view (FPV) sharing (or first person video sharing) systems provide a feeling of seeing from another person's eyes [15,17,19,20]. Existing systems have revealed that FPVs are suitable for movement synchronization in distributed settings [12]. FPVs also give rise to an illusion of being within another people's body [15]. We were curious to know whether the features of FPVs could help LDRs to feel each other's physical embodiment, feel more deeply immersed in the remote location, and feel a greater sense of social presence. Such views might allow LDR couples to create new experiences to help them feel close. Yet designing FPVs that stream video between two partners raises interesting questions around how the video should be displayed and what effects it will have on the couple.

We first present our design of *MyEyes*, a FPV video streaming technology probe [11] made with cardboard goggles and smartphones. With MyEyes, partners exchange

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first person views with each other to see exactly what each other sees (Figure 1). Distance-separated partners see each other's view on their displays where it can overlap their own view (Overlapped View), be placed above it (Horizontal View), or at the same time but each view is seen with a different eye (Split View). These views combine research from several past systems, which were designed for more general interactions and not LDRs [12,15–17]. We added a new type of view called Split View. We also focused on creating a low cost design that might be more easily adopted and used by couples in everyday situations, rather than being restricted to research labs or scripted environments [12,15–17].

We studied the technology probe using mixed methods with 12 couples—8 had been in a long distance relationship in the past and 4 had not. Couples compared the three different views for displaying video where we explored couples feelings of social presence—the feeling that you are in the same room as someone [3]—and body ownership—the ability to feel like you are in another person's body [7,23] as means to empathize with a person. We also explored how participants felt they might use the system as part of a LDR. Participants preferred the Overlapped View and it provided the most feelings of Co-Presence. Both Overlapped View and Split view provided strong feelings of 'body ownership', the feeling of being in another person's body. Horizontal View, however, received the highest score for 'mutual understanding' (e.g., feeling empathy for another) among the three interfaces. Couples enjoyed using MyEyes and wanted to use it as part of their relationship in the future. The FPVs were especially valuable for performing shared acts that were synchronized across locations, as well as activities that could be done 'in' the remote location. These were not always easy though and we suggest directions to circumvent the challenges.

RELATED WORK

Long Distance Relationships and Technology

Couples in LDRs need regular communication to maintain their relationship [22]. Here they rely on computer-mediated communication tools to overcome their physical separation [25]. A study of LDRs using video chat [25] describes the routines couples have for communicating over distance. Results show that couples highly value seeing their partner and sometimes use video chat to experience a sense of 'shared living' together [25]. Yet existing video chat systems (e.g., Skype) lacked mobility and support for conversing during shared and independent activities [25].

Recurring themes amongst communication systems designed for LDR couples are connectedness and playful interactions. For example, BreathingFrame [18] is an inflatable photo frame that enables couples to feel emotional connectedness by delivering a breathing signal to an inflatable surface. WearLove [14] is a wearable device for couples to stay connected through a tree-planning game. Gooch and Watts explored the design of systems to support touch and hand holding over distance [9,10]. Participants enjoyed a sense of personalization and playfulness [10]. They suggest designing for openness and flexibility [9]. Flex-N-Feel used a pair of interconnected gloves to allow couples to share touch over distance [27]. Again, couples enjoyed playful experiences with the prototype.

Similar to our study, Baishya and Neustaedter [1] studied a video technology probe called In Your Eyes for LDRs. The probe used smartphones with Skype in auto-answer mode and placed in shirt pocket to provide an 'anytime, anywhere' video chat experience, though it did not provide a true FPV as we do with MyEyes. One couple highly valued In Your Eyes because it allowed them to spontaneously interact with one another and be player [1]. A second couple felt the prototype infringed on each other's autonomy and privacy. Based on the aforementioned designs and studies, we aimed to similarly create playful experiences within the design of MyEyes while focusing on providing feelings of connectedness and social presence.

First Person View Sharing

FPV sharing utilizes devices like head mounted displays (HMDs) to provide a feeling of seeing from another person's eyes [15,17,19,20]. Researchers have studied FPVs in collocated collaboration and skill transition [5,15,17] and found FPVs to be valuable for enabling users to see from a remote perspective and create a physical embodiment in distributed spaces [15]. For example, Kasahara et al. [15] studied a four-view FPV system called Parallel Eyes for groups of people to investigate the difference of FPV in a one-way 'shooter-watcher' model (one user streams and the other watches the stream) compared to a mutual view sharing model (both users stream and watch both streams). A series of workshops explored activities such as shaking hands, drawing, and playing tag). They found a symmetric configuration such as first person view exchange could help people to understand complex information from multiple sides to enhance communication with people in a distributed setting [15]. Yet people sometimes lost their own sense of embodiment because they became overly focused on their partners' first person views [15]. While their system was similar to ours, Parallel Eyes was not evaluated for its ability to support specific relationship needs such as with long distance couples. We were interested to know whether the advantages of symmetric FPV exchange could help LDRs to feel a sense of social presence.

Similar to our study, Kawasaki et al. [17] and Iizuka et al. [12] designed and studied a system with a swapping view (users only see the remote view) and blended view (the scenes from local and remote side were merged in the same frame, similar to our Overlapped View). They found that merging the images from two sides on the same video frame could help users synchronize their movements easily. This inspired our interface design of MyEyes where we include a similar view as part of our design and evaluation.

Social Presence and Body Ownership

Researchers commonly study *social presence*—the feeling of being with someone in the same room—in mediated environments to compare media interfaces and understand user behavior [3]. The Networked Minds Measure [2] breaks down social presence into three sub-categories: Co-Presence, Psychological Involvement and Behavioral Engagement. It is considered to be a valid and reliable measurement for social presence and it has been used in other similar research. For example, JackIn Head was an omnidirectional wearable camera that streamed one-way video to a remote user [16]. The researchers discussed that their one-way FPV system could lead to higher Co-presence and Psychological Involvement for the person who receives FPV image and less social presence for the person who sends FPV image. Different from JackIn Head, our system provides two-way FPV exchange: one can see his/her own view and their partner's view at the same time.

Body ownership is the feeling that a body or body part is one's own [7,31]. Body representation consists of two significant factors, body schema and body image [7]. The body schema is an internal standard built based on people's sensory experience while body image is the visual perception of body appearance [7]. In some circumstances, such as the Rubber Hand Illusion [4], simulating a tactile or movement experience while changing the visual perception of the body can give rise to misunderstanding body ownership (e.g., feeling a rubber hand is my own hand) [26]. This can give rise to fascinating illusions of gender, race and age swapping [21,23,26]. By manipulating the chatting environment, we can utilize the 'rubber hand' illusion and let users feel as if they can 'touch' their partners' hands in an effort to strengthen intimacy. The study of Flex-N-Feel revealed that couples were interested in being able to touch each other remotely and that touch could impact couples' feelings of intimacy [27]. However, it is difficult for people to exchange a 'real' physical touching experience without sophisticated telepresence robots or vibrotactile technologies. As a result, we wanted to investigate whether our prototype could simulate a feeling of physical touch by manipulating one's sense of body ownership when using FPV video streaming.

THE DESIGN OF 'MYEYES'

Compared to traditional video chat systems, FPV video conferencing has typically required sophisticated and expensive equipment with pre-configured and scripted testing environments (e.g., [15,16]). Our design goal was to see if we could create a low-cost design that might be more easily adopted and used by couples in normal everyday situations rather than being restricted to research labs. Couples use video chat in various locations and at different times [25]; thus, portability and ease-of-use are critical factors for system design.

MyEyes is made with cardboard goggles and Android smartphones. We made a video chat app for web browsers with WebRTC. Local and remote video feeds show on the screen in real time. Users can wear the goggles on their head using the head strap and adjust lenses by pulling the 'ears' on the side of the cardboard. Our goal was twofold. First, we wanted to create strong feelings of social presence between partners. Thus, we wanted partners to feel like they were actually in the remote location and seeing through the eyes of one's partner. Second, we wanted to create a sense of body ownership. That is, we wanted partners see each other's body, almost as if it was their own. This might help to create feelings of connection, intimacy, and empathy with one's partner. We investigated what representations of visual information were suitable for creating feelings of social presence and body ownership by designing three interfaces: Split View, Horizontal View and Overlapped View (Figure 2). The first view has not been a part of existing systems, while the latter two views build on prior work. The views can be toggled by researchers remotely.

Figure 2. Split (top left), Horizontal (top right) and Overlapped (bottom) views.

Split View

In Split View, users' left eye and right eye see different video feeds: the left eye shows one's local view and the right eye shows the remote user's video feed. This allows users to filter the local or remote view by closing their left or right eye. Leaving both eyes opens allows users to see a merged view containing both video feeds. We designed this view as neuroscientists have found that visual information coming from one's left and right eyes are handled by different hemispheres of the brain but can be processed integrally [6,28]. Split View represents a flexible form to present visual information in FPV that enables users to choose which view to focus on—their own view or their partner's—and allows users to mix local and remote video feeds through brain processing. Yet we do not know if such a viewing mechanism would be an understandable and appropriate method for couples to feel a strong sense of social presence and body ownership with their partner.

Horizontal View

In Horizontal View, the local and remote video feeds are stacked vertically, one on top of the other. This is very

similar to Parallel Eyes [15] which has four parallel videos shown at the same time. It is also similar to how Skype or Google+ Hangouts shows multiple video feeds tiled one above each other. Horizontal View is likely most familiar to people and so we wanted to see how this familiarity might merge with the ability to see the remote location through a FPV. Yet it is not clear whether this view can help couples feel a strong degree of social presence and body ownership.

Overlapped View

We merged two video feeds in the same frame in an Overlapped View, akin to the 'blended view' proposed by Iizuka et al [12]. They found this visual coupling style required less effort when people tried to synchronize their movements. We wondered if we could use the advantage of this interface to simulate a 'physical touch' without sophisticated telepresence robot or vibrotactile technologies. The answer could provide a new solution to help LDRs interact, experience and bond with each other.

METHODS

The goal of our study was to evaluate MyEyes to understand what visual representations of FPVs could help couples gain a stronger feeling of social presence and body ownership. We also wondered how couples would like to use a FPV and what activities they would like to share over the system. We designed a repeated measures study with three tasks and an exploratory session.

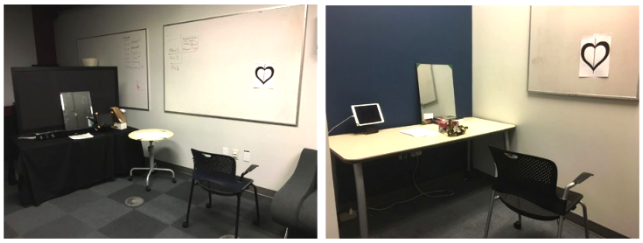


Figure 3. Two study rooms located on different floors. Each room has a whiteboard, a heart-shape sticker, a chair, a mirror, and an iPad.

Participants

We used online forums, posters, and in-class advertisements for the recruitment of 12 couples (N=24) through snowball sampling. The participants were marked from P1 to P24. The participants all lived in Vancouver, Canada and none were currently in a LDR. Four pairs were married. Most of participants had been in relationship for more than one year except for P21-P22 (four months) and P19-P20 (eight months). Eight couples had experienced long distance relationships before with the length from two months to three years. The age range was from 21–31 (M=25.83, SD=2.94). 11 couples were heterosexual, and one was homosexual. The occupation of the participants included college students, designer, engineers, sales person, and logistics coordinator. Participants signed consent forms prior to the study. Although couples were tested in pairs, they gave responses and were interviewed individually.

Experiment Design

We designed a within subject experiment with the three different interfaces. The independent variable (IV) is the interface style, which has three levels: Split View **(S)**, Horizontal View **(H)** and Overlapped View **(O)**. The dependent variables (DVs) are the responses from a questionnaire concerning social presence and body ownership. Our 11-item questionnaire was derived from previous experiments of other researchers on social presence and body ownership [2–4,8]. We gave each question a label for describing our results (Table 1). There were three rounds of testing for each pair of participants. For each IV, participants used MyEyes for three tasks followed by an exploratory session.

We hypothesized Overlapped View would do better than the other two views for social presence, especially for Co-presence and Behavioral Engagement because it provides an immersive experience and requires little effort for synchronization [12]. We also hypothesized that Overlapped View and Split View would receive higher ratings for "body ownership of partner" and provide a feeling of "I am touching my partner's hand" because these two views mix the perception of one's local hand and remote hand to provide an immersive feeling [26].

Procedure

We first asked participants to fill out a survey to get basic information of their age, occupation, and the relationship with the partner. The survey also includes the questions

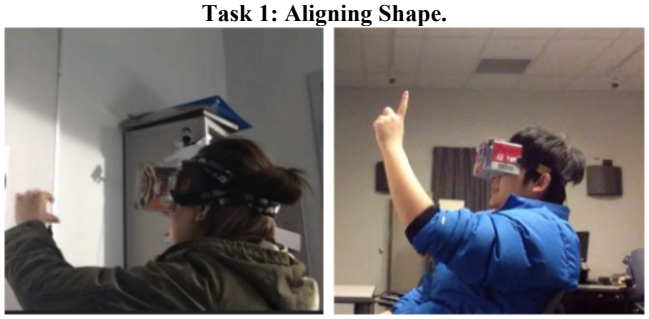
Table 1. The 11-item (Q1-Q11) questionnaire used after each round of interface testing. Each question has a code. Q1-Q7 relate to social presence and others relate to body ownership.

Question 1: **Connectedness**	I felt more connected to my partner compared to a normal video chat like Skype when using the interface.
Question 2: **Mutual Awareness**	I felt as if I was in the same room with my partner when using the interface.
Question 3: **Isolation**	I sometimes forgot about my partner and concentrated only on doing my own task when using the interface.
Question 4: **Mutual Understanding**	I could easily understand what my partner was doing when using the interface.
Question 5: **Difficulty in Synchronization**	It was difficult for me to synchronize my movement with my partner when using the interface.
Question 6: **Seeing Through**	I felt like I was looking through my partner's eyes when using the interface
Question 7: **Similarity of Collocated Activities**	I felt like I was with my partner just like doing our daily activities (such as having dinner together, doing exercise together)?
Question 8: **More Hands**	I felt as if I had more than two hands when using the interface.
Question 9: **Hand Transition**	I felt as if my partner's hand changed to my hand when using the interface.
Question 10: **Stroking Partner**	I felt like I was stroking my partner's arm in Task 3 when using the interface.
Question 11: **Being Stroked**	I felt like I was being stroked by my partner when using the interface.

about their previous experience in LDRs, how frequently they use video chat, and if they have had motion sickness in virtual reality before. Then we gave a short demo of MyEyes. Next, we put couples in different rooms located on two different floors of the same building. The setting inside the rooms is shown in Figure 3.

In order to eliminate observer effect, researchers did not stay in either room. We sent all instructions through Skype on an iPad and video recorded participants' movement in the room. A switch on the system's web page was used to change the interface remotely so we did not have to enter the room. Participants then completed the study tasks.

Task 1: Aligning Shape.



Task 2: Constructing Alphabet.

Task 3: Arm Stroking.

Figure 4. Study tasks performed with each MyEyes view.

Task 1: Aligning Shape - Participants sat on a chair, facing the white board. We asked participants to look at a heart-shape sticker on the whiteboard and make it overlap in each of their views. If they were using the Horizontal View, we asked them to make the shapes vertically aligned instead. This task requires view synchronization for couples. We imagined the heart shape to be a metaphor for the couple's relationship where the task could help participants quickly familiar themselves to using MyEyes at an entry level.

Task 2: Constructing Alphabets **-** Participants sat on a chair facing the white board. We asked them to draw three different English letters in the air using their hands at the same time as their partner. This task requires the coordination of hand movement and view synchronization. Gestures and body acts are typical and common in video communication [24]. The interaction of bodies provides couples with opportunities to express physical intimacy.

Task 3: Arm Stroking **-** We asked participants to stretch their left arm in front of their eyes and try to make the arm of both partners overlap in their view. If they were using the Horizontal view, we asked them to make the arms vertically aligned instead. Then we asked them to use their right hand to gently and slowly stroke the left arm of their partner synchronously. We imagined this might resemble a familiar intimate physical act. This task lasted for one minute. This task requires virtual touching, the coordination of hand movements in motion, as well as view synchronization.

Exploratory Session **-** Following the three structured tasks, participants completed an exploratory session that lasted for ~3 minutes. During the exploratory session, we did not give specific tasks to our participants. The goal of exploratory session was to observe what kind of activities couples might be interested in doing when using MyEyes.

The level of the difficulty for the tasks increased as they went because we assumed FPVs would be relatively new for participants. Seven participants did not have prior experience using head mounted displays or similar technologies. Hence, we setup the tasks to help them smoothly bridge into our experiment. The order of the interfaces was counterbalanced and we had 12 pairs of participants so all orders of testing were tested twice. The three tasks lasted for ~10 minutes in total. After each round of testing (each IV), we asked the participants to fill out the questionnaire. We used a 7-point Likert scale in the questionnaire. After three rounds of testing, we conducted one-on-one interviews that were audio recorded. A complete experiment for a couple took 50-60 minutes.

Individual interviews were conducted after participants completed all three rounds of testing (seeing all IVs). Here we asked them about their reactions to the views, what worked well or was challenging with the views, and how they felt they would use MyEyes in a LDR, if at all.

DATA ANALYSIS

We conducted a one-way repeated measure analysis since our participants were exposed to all three conditions. We applied a Shapiro-Wilk test for testing normality of our data. The results showed that none of the responses for the 11 questions were normally distributed ($ps < .0007$). We hence conducted Friedman tests as the nonparametric measure and Wilcoxon Signed Rank tests as post-hoc analysis comparing the effect of interface type on social presence and body ownership. There were three matched pairs for comparison (Horizontal–Split, Horizontal–Overlapped and Overlapped-Split), so we applied Bonferroni correction, resulting in a significance level at $p < .017$ in post-hoc tests. Statistical tests were run in SPSS.

We used thematic coding to find the main categories and themes in our interview transcripts and video recordings.

We finalized General Experience, Synchronized Activities, and Activities 'In' the Remote Location as the main themes.

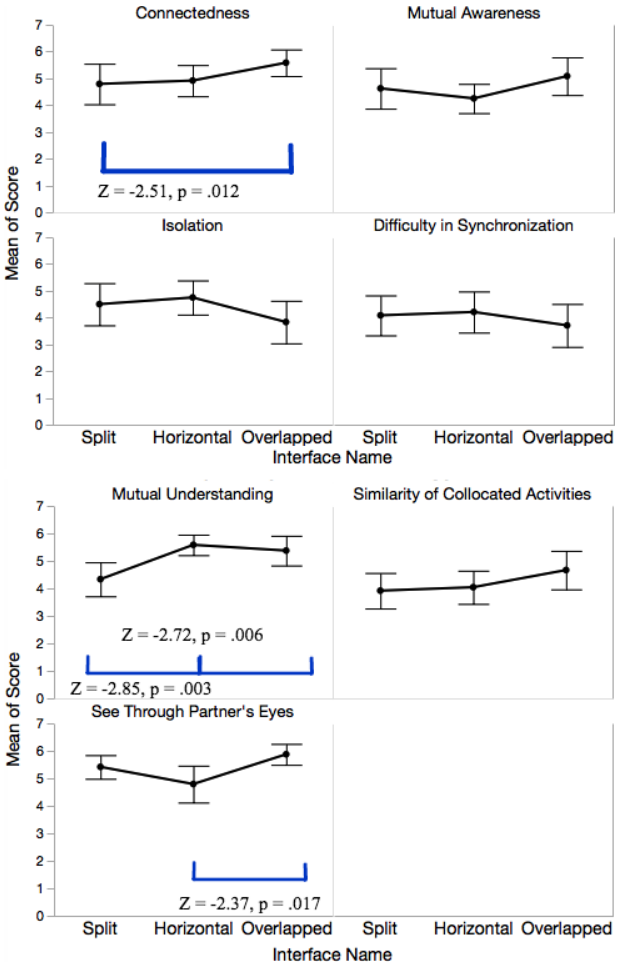


Figure 5. The line chart depicts the mean and confidence interval (*CI* = .95) of score for questions related to social presence across three interfaces. (Q1-Q7)

QUANTITATIVE RESULTS

Social Presence

Questions 1, 2 and 6 in our questionnaire related to Co-presence, questions 4 and 7 related to psychological involvement and questions 3 and 5 related to behavioral engagement. As shown in Figure 5, we calculated the means for every combination with a confidence interval bar. Freidman tests showed that there was a statistically significant difference in Connectedness ($\chi 2(2) = 6.86$, $p = .031$) and Mutual Understanding ($\chi 2(2) = 11.79$, $p = .002$) depending on which interface was tested for couples. Post-hoc tests revealed that Overlapped View had a higher score than Split View for Connectedness ($M_{O\text{-}Q1} = 5.58$, $SD_{\text{O-Q1}} = 1.18$, $M_{S\text{-}Q1} = 4.79$, $SD_{\text{S-Q1}} = 1.79$). Overlapped View also had a stronger feeling of Seeing Through a partner's eyes than Horizontal View ($M_{O\text{-}Q6} = 5.88$, $SD_{\text{O-Q6}} = .90$, $M_{H\text{-}Q6} = 4.79$, $SD_{\text{H-Q6}} = 1.59$). In terms of Mutual Understanding, the Horizontal View had the highest score amongst the three interfaces ($M_{H\text{-}Q4} = 5.58$, $SD_{\text{H-Q4}} = .88$, $M_{O\text{-}Q4} = 5.38$, $SD_{\text{O-Q4}} = 1.28$, $M_{S\text{-}Q4} = 4.33$, $SD_{\text{S-Q4}} = 1.47$), which indicated that Horizontal View was the easiest for couples to understand what their partner was doing. We could draw the conclusion from the Networked Mind Measure that the Overlapped View created a stronger feeling of Co-Presence (More Connectedness and feeling of Seeing Through a Partner's Eyes) whereas Horizontal View had better Psychological Involvement (higher score in Mutual Understanding).

Body Ownership

Our measure of body ownership was derived from questionnaires from researchers studying rubber hand illusions [4,7]. Figure 6 shows that for each question related to body ownership, Horizontal View had the lowest means. Freidman tests showed that there was a significant difference in Hand Transition ($\chi 2(2) = 10.23$, $p = .005$) and More Hands ($\chi 2(2) = 6.57$, $p = .037$). Wilcoxon Signed Rank tests showed that Split View had a higher score than Horizontal View for Hand Transition ($M_{S\text{-}Q9} = 5.08$, $SD_{\text{S-Q9}} = 1.70$, $M_{H\text{-}Q9} = 3.54$, $SD_{\text{H-Q9}} = 1.50$). Overlapped View had a higher score than Horizontal View in feelings of More Hands ($M_{O\text{-}Q8} = 4.33$, $SD_{\text{O-Q8}} = 1.76$, $M_{H\text{-}Q8} = 3.50$, $SD_{\text{H-Q8}} = 1.29$). Moreover, Overlapped View and Split View both had significantly higher scores for feelings of Stroking Partner ($M_{O\text{-}Q10} = 5.00$, $SD_{\text{O-Q10}} = 1.50$, $M_{S\text{-}Q10} = 4.92$, $SD_{\text{S-Q10}} = 1.64$, $M_{H\text{-}Q10} = 3.83$, $SD_{\text{H-Q10}} = 1.47$). In essence, both Overlapped and Split View provided higher body ownership of participants' partner than Horizontal View. The difference between Overlapped and Split View was not significant in the responses related to body ownership.

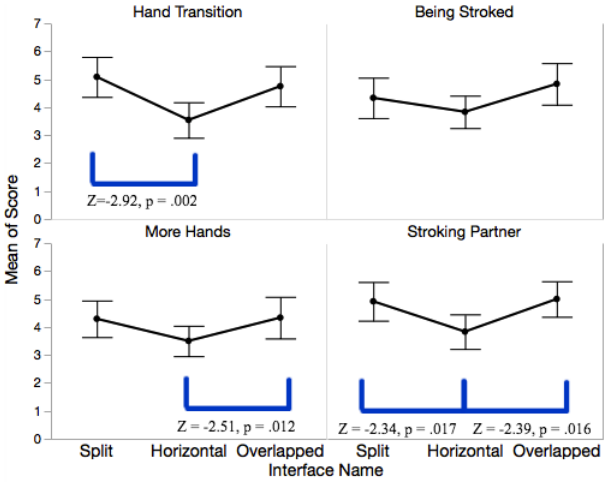


Figure 6. The line chart depicts the mean and confidence interval (*CI* = .95) of score for questions related to body ownership across three interfaces (Q8 – Q11).

Preference

We asked participants to rank their preferences for the three interfaces in the post-experiment interview. The results showed that 75% (18 out of 24) participants said that Overlapped View was their favorite. 62.5% (15 out of 24) participants said Split View was their least preferred. Thus, although Split View provided relatively higher body ownership than Horizontal View, participants did not like it.

Despite relatively lower scores in Mutual Understanding, Overlapped View still dominated couples' preferences. Figure 7 shows the distribution of participants' preference.

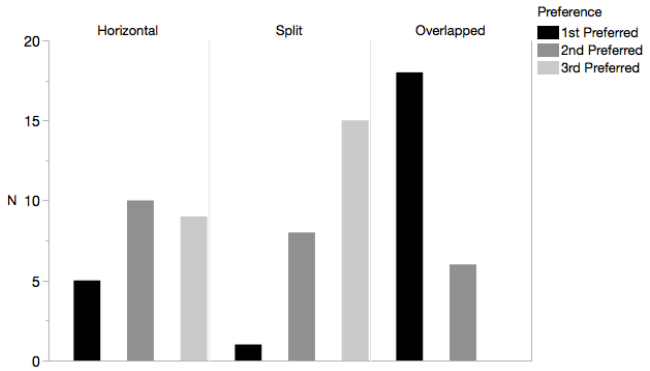


Figure 7. The bar chart showing participants' ranks of preference over three interfaces. ("1st Preferred" means "Favorite"). Overlapped View has zero "3rd Preferred".

QUALITATIVE RESULTS

We now describe our qualitative results from the post-study interviews, conducted individually with participants.

General Experience

Nearly all participants said they enjoyed the experiment and felt connected to their partner when doing the tasks. Descriptions like "cool idea", "novel experience" and "like the interactivity" were said about the system. Being able to see what one's partner was seeing was acknowledged by participants as an intriguing design characteristic. Many felt it was highly intimate.

"I found the idea of 'seeing through partner's eyes' was quite interesting." - P2, Female

"It was a different experience compare to Skype. You can see them in a more personal way. – P7, Male

"Very cool, very intimate!" – P23, Male

The design was not with its flaws though. Several participants said that they felt confused when doing tasks in Split View. This was largely because it was tiring to switch between one's left and right eye in order to see each view separately. Participants said that it was easy to understand what their partner was doing in Horizontal View, similar to our quantitative results.

"The Split View was very disorienting, my brain… I don't know what I want to see." – P23, Male

"The Horizontal View is easier for me. If I don't want to look at her screen I can do that but with the others I can't ignore. The split one made me really dizzy." – P19, Female

A few participants felt motion sickness when they or their partner moved too fast and it was difficult for them to quickly understand what was happening. Some participants mentioned that the network quality and the resolution could also affect their experience if used more regularly.

Synchronized Activities

In our post-experiment interviews, participants told us that one of the main benefits of MyEyes was the ability to synchronize movement and actions with their partner. This led to a sensation that they were actually touching their remote partner's hand because they could both be moving their hands at the same time, and this act was seen in their own view. In these cases, it was important to be able to focus on views from both locations at the *same time.*

"In Overlapped View, like the sensation is on my hand but because it was nicely aligned, I stroked my hand but I saw her hand. It was a good experience." – P5, Male

They told us that synchronization became especially salient in Overlapped View and Split View. This result echoed our quantitative results about their preference of interfaces and higher ratings for Overlapped and Split View in creating feelings of body ownership and social presence.

"And I really felt something like he was touching my hand or I was touching his in Split and Overlapped View. This gave me physical intimacy." – P2, Female

Participants said they wanted to use the synchronization from MyEyes to perform other acts with their partner that they felt traditional video chat systems were not capable of supporting in a rich way. For example, P14 said she would like to use MyEyes to work-out with her boyfriend:

"I would do some activities like push-ups together. My problem was that I was not going low enough. We tried to do push-ups over long distance before. We put the phone, Skype, do the push-up in front of it. Then he can see whether I am going low enough. Like video chat coaching. [But with MyEyes] I can see what he sees then we could coordinate to force to go as low as he does."–P14, Female

The benefits of synchronization were further elucidated during the exploratory sessions. More than half of our participants performed 'playful activities' where each of these acts leveraged the fact that body movements could be synchronized. For example, four couples played 'Rock, Paper, Scissors' with their hands (Figure 8) and one couple played a hand clap game (one tried to clap the other's hand remotely while the other was trying to escape). Other activities included high-fives, finger snaps, clapping, and forming heart shapes in the air with one's hands. For each of these activities, the activity benefitted from partners being able to do their hand movements at the same time.

"We tried a hand clapping game with our hands in overlapped view. The experience was good, I didn't play the same game in the other two interfaces because we can't." - P1, Male

"We played Rock Paper Scissors. And we tried to shape heart forms with our hands. Clapping, basically. The only

thing that I can see from her was her hand. So, do something with the hands. "– P5, Male

Some participants tried to overlap their shoes or feet (Figure 9). This revealed that although hand movements dominated the exploratory sessions, participants were also curious about the ownership of other parts of their body.

P21 and P22 played tic-tac-toe in both Split View and Overlapped View on the white board. They used markers to draw their moves so they were visible in the remote space. As they played, they took turns writing on the board. While their movements of drawing on the board were not synchronized, they had to pay careful attention to synchronize the game of tic-tac-toe on the whiteboard between the rooms or pen markings would be misaligned.

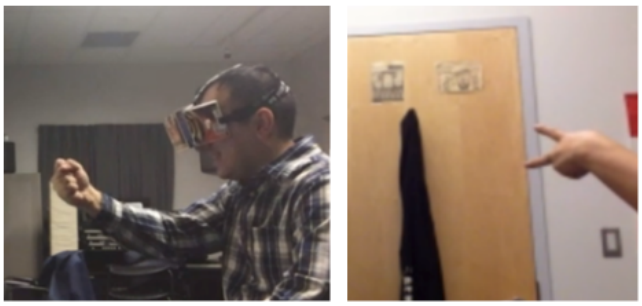


Figure 8. Rock Paper and Scissors in the exploratory session.

Figure 9. Participant looking at his feet.

Figure 10. Participant trying to pick up a chair at his partner's side.

While most participants agreed that the synchronization could help them feel like they were there together with their partner, P1 felt that sometimes the need to try and synchronize movements took away from the sense of feeling one's partner. That is, the task of trying to synchronize made one concentrate on it, rather than the associated feeling of social presence.

"When we were trying to synchronize our stroking, my efforts were on synchronizing the movement rather than to feel her. I would say when she stroked and I stopped, or when I stroked and she stopped, that feeling is better than do the stroking all together." - P1, Male

Activities 'in' the Remote Location

Participants also found it valuable to engage in activities with MyEyes 'in' the remote location where they focused on the view of the remote location and not their own. In these cases, it was not necessary to have synchronized movements.

"I think the best case is, I can see his surroundings but I can also merge only my hand movement or gestures in the surroundings to mix with his. Sometimes I don't need to see my side." – P2, Female

In the exploratory session, one participant tried to read a book through her partner's eyes. Some couples explored the rooms and showed artifacts (e.g., Lego blocks, snacks and pillows) to their partner. They usually came at a very close distance with the artifact and 'stared' at it while they were explaining what it was to their partner. In many cases, one participant sat on a chair while his/her partner explored the room 'on behalf of him/her'. We found that participants often wanted to go beyond just seeing to be able to interact with objects in the remote location, sometimes held by the remote partner. For example, a participant collaborated with his girlfriend to try to pick up a chair from his girlfriend's hand (Figure 10).

The environment sometimes made it difficult to perform the aforementioned activities. This involved challenges with lighting, the complexity of video backgrounds, and the speed at which one could move (moving too quickly could cause disorientation). Many participants said they could not easily differentiate the video feeds when backgrounds were dark or the background had too many artifacts and colors. This was especially the case for Overlapped view. Yet the ability to easily see only the remote view was essential for performing activities 'in' the remote location.

"When we were in Overlapped view, if my background was dark and her was bright, I can barely see my own view." - P1, Male

"I was by chance facing the white board against the wall and all I could feel was all his seeing. I suddenly felt a larger space in front of me although I was facing a wall." – P16, Female

Participants had workaround for overcoming environmental problems. Here they utilized lighting and different background colors to 'switch' between seeing the local view and remote view. For example, if one looked at a dark area in their room, it was easier to see the remote location because the view of their own space was dark.

"I was facing the white table on purpose." – P2, Female

Some participants talked about the transparency of remote and local images in Overlapped View. They felt it would be beneficial to be able to adjust the transparency of the images or be able to only show a particular part of one's body in the video such as only showing a hand interacting within the remote partner's location.

Participants imagined using MyEyes outside of the study room in other similar ways where one could focus on 'being' in the remote location. For example, P5 talked about his

desire to use MyEyes to support virtual visits and share dinner at a restaurant with his remote partner.

"This (MyEyes) has more capability, like you go somewhere new and you wanna share the new place that you are seeing, or in the restaurant, show her the food. It has more capability than the current methods (Skype and Viber)." – P5, Male

Other participants wanted to cook, explore new places, and some even wanted to 'go to' a remote concert.

Privacy and Autonomy

When asked about how they would use MyEyes outside of the study context as a part of real life, two main privacy concerns arose. First, some participants worried that their partner would be able to see more of their environment than they might be comfortable showing because views would not be stationary, akin to a laptop pointing in a single, sometimes carefully selected, direction. Controlling where one looked at in a room could be quite difficult and glances in different directions might be easily seen by one's partner.

"But with this (MyEyes), she could probably see everything of what I am doing. It's not a good feeling that I have no control over what she can see." – P19, Female

"When we separate, if he goes out for a drink and he says he is studying at home, with Skype, he could just quickly pan the phone or ask his friends to go away. But with this, he will have nothing to hide from me. If I ask him to switch to back camera in Skype, he might not be willing to. But with this, by nature he has to switch it on." – P16, Female

Second, participants talked about not wanting to use MyEyes in a public environment where it could be seen by others. Some thought about and wanted to perform acts that might be more private in nature (e.g., touching). For example, two participants felt that it was socially awkward to use the system as part of a research study because touching another person was sometimes quite intimate.

"It's awkward (touching my hand in the study room). But I think it would be less awkward if you are at your own home."- P19, Female

We had posited that having a sense of body ownership over one's remote partner may cause privacy concerns (e.g., 'giving up' one's body to a partner); however, none of our participants brought this up as a concern.

DISCUSSION

In this section, we discuss: (1) The benefits and drawbacks of the three view styles for FPV systems; (2) Design implications for FPV systems; and, (3) Generalizability and limitations of our work.

First Person Views and Physical Intimacy

We measured social presence through the Networked Minds Measure, which breaks down social presence into Co-Presence, Psychological Involvement and Behavioral Engagement. Quantitative results show that the Overlapped View was the most preferred by our participants and it provided the strongest feeling of Co-Presence. However, contrary to our hypotheses, the Psychological Involvement score (feelings of mutual attention, empathy, mutual understanding) for the Overlapped View was not the highest. Yet Overlapped View provided a strong sense of "being with my partner" in a remote setting. This suggests that couples would value future designs that have an Overlapped View; however, such a view could be improved to better enhance feelings of empathy and mutual understanding (Psychological Involvement). The Horizontal View had the highest score for mutual understanding because people could easily distinguish their view from their partner's. This means that it might be possible to increase feelings of empathy in the Overlapped View by giving users clearer indications of which views are local vs. remote when they are merged in the same frame. Of course, this should be tested with further design work.

One of our study goals was to explore whether we could use a rubber hand illusion to create a sense of virtual touching between partners. Our results showed that Overlapped View and Split View *could* provide such a feeling. These results extend the work by psychologists and neuroscientists who have found that gender, age, and race swapping is possible by changing feelings of body ownership through the effect of a rubber hand illusion [8,21,26]. Previous work on FPVs showed that people sometimes lost the feeling of their own body and felt like they 'took on' the body of another person; this was reversed when they bumped into an object in their own location [15]. We extended these results to show that a similar feeling occurs when distance-separated couples are connected in FPVs. Moreover, given that couples in our study liked exploring a variety of different activities with FPVs, our results imply that FPV video systems could be a possible solution for offering physical intimacy between partners by simulating embodiment within a partner's body. Future FPV systems could focus on other intimate acts such as cuddling, kissing, or even sexual activities for LDRs. Our research suggests promise for such explorations.

Shared Activities over Distance

Our qualitative results showed that participants liked to do a range of *synchronized activities* together over distance. These benefitted from time-sensitive body movements and seeing both views. These activities involved very short reaction times and precise collaboration. A clear advantage for FPVs was the ease at which users could synchronize and coordinate their movements. These results show that couples could benefit from FPV systems for supporting such activities. However, future designs will need to pay careful attention to lighting and the complexity of backgrounds within the video feed as these can greatly affect users' experience when mixing perspectives from different sides. Participants also imitated the sound of clapping. It may be valuable to enable more sensing dimensions (e.g., smelling, hearing) in FPV systems.

Participants also found value in their ability to do activities 'in' the remote location where they would interact with objects that they could see in their remote partner's view. These activities did not require synchronization between partners in terms of what they were doing, though one partner would have to maintain a relatively fixed view during interaction. In these activities, users may not always focus on both views in a FPV system and users would find value in mechanisms that could allow them to filter out some or all of their own view. Split View provided such capabilities though the way users controlled it was tiring (closing and opening an eye). Such interactions would likely not be possible for activities that took place over a long period of time. Future work should explore how to augment views such as only displaying portions of a person's body in the remote view, e.g., showing only remote hand gestures in an Overlapped View. This would allow users to perform an action in the remote user's environment while only seeing their relevant body parts. Research could also explore other interaction techniques for toggling the visibility of views without using one's eyes, e.g., a toggle button as part of a smart watch.

Many long distance couples face time zone challenges and busy schedules; thus, it could be hard to find the time to have a shared activity [25]. One could imagine extending systems like MyEyes to provide forms of asynchronous video sharing where one partner might record a video from a first person viewpoint such that another could watch it from that same viewpoint later. This type of system would be difficult to use for the synchronized activities did in our study but could work well for activities focused on being 'in' the remote space and creating a stronger sense of mutual understanding and empathy.

Privacy

Like most video-based communication systems, privacy issues arose. People are not used to having views of remote locations where one can see everything that another person looks at. This caused concern for some participants in case something was shown that they were not comfortable with sharing. Participants said they did not want to show everything from their eyes to their partner and they desired greater control over what they streamed. This suggests being able to toggle one's own stream on or off in an easy way, or being able to blur out or block portions of the shared video view. Of course, it would be challenging to design interactions to regulate such views. A blurred portion of a video view, for example, may also raise more questions (e.g., why is that portion blurred?). Other techniques that replace background content may be more appropriate so that it is not obvious to the remote user that the video feed has been altered. Naturally, there are social ramifications to such designs and the honesty/trust that is found or expected within a LDR relationship.

Participants also said that the environment had an impact on how they would use MyEyes. This indicates that couples might use FPV systems differently in a home environment (more acceptable for intimate acts) than in a public space. In these situations, designers should consider designing for a larger range of activities than participants engaged in.

Limitations

Our research focuses on long distance couples though, for pragmatic reasons (e.g., it would be hard to study remote partners who might be in varied locations around the world), we had to conduct the study with couples who were not currently in a LDR. We tried to mitigate the effects of this difference by having eight pairs of participants who had previously been in a LDR before. Many of them compared the experience of using MyEyes with their previous experience of using Skype-like systems in a LDR. These comparisons were based on their real personal experiences. We did not have a large enough sample to quantitatively compare those who had been in a LDR in the past vs. those who had not; however, the qualitative reactions we received from participants did not reveal any obvious differences. Nonetheless, our research is limited by our participant sample. People presently in a LDR would likely not be able to see each other or have any physical interactions in person, which could cause different results to appear in a study like ours where they may have additional longing to be together. The other limitation in our study is that the age range of our participants fell within a young census (21-31 years old). Future research should explore participants within real LDRs and have diversity in different age groups.

CONCLUSION

MyEyes is a first-person view sharing video chat system for long distance couples. Users are able to exchange their first person view as if they are looking through their partner's eyes. We designed three different interfaces (Split View, Horizontal View and Overlapped View) and ran a mixed method study with 12 pairs of couples. Our quantitative results showed that most couples preferred Overlapped View and it provided the strongest feeling of co-presence. Both Split View and Overlapped View could help couples create a sense of body ownership with their remote partner. The qualitative results showed that couples found MyEyes novel and interesting where intimate experiences can be instantiated. We summarized the different type of activities that partners felt would be beneficial with FPV systems. Here we found that synchronized activities as well as those that allowed one to participate 'in' a remote location was highly valued. Future designs should carefully consider privacy concerns and how views can be controlled by users. Overall, FPV systems can be an intriguing way for couples to stay connected and build a strong relationship when they are geographically separated.

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