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

by

Rui Pan

B.Eng., University of Electronic Science and Technology of China, 2015

Thesis Submitted in Partial Fulfillment of the
Requirements for the Degree of
Master of Science

in the
School of Interactive Arts and Technology
Faculty of Communication, Art and Technology

SIMON FRASER UNIVERSITY

Summer 2017

Approval

Name: **Rui Pan**

Degree: **Master of Science**

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

Examining Committee:

Chair: Dr. Bernhard E. Riecke
Associate Professor

Dr. Carman Neustaedter
Senior Supervisor
Associate Professor _____

Dr. Chris D. Shaw
Supervisor
Professor _____

Dr. Scott Bateman
External Examiner
Assistant Professor
Faculty of Computer Science
University of New Brunswick _____

Date Defended/Approved: _____

Ethics Statement

The author, whose name appears on the title page of this work, has obtained, for the research described in this work, either:

a. human research ethics approval from the Simon Fraser University Office of Research Ethics

or

b. advance approval of the animal care protocol from the University Animal Care Committee of Simon Fraser University

or has conducted the research

c. as a co-investigator, collaborator, or research assistant in a research project approved in advance.

A copy of the approval letter has been filed with the Theses Office of the University Library at the time of submission of this thesis or project.

The original application for approval and letter of approval are filed with the relevant offices. Inquiries may be directed to those authorities.

Simon Fraser University Library
Burnaby, British Columbia, Canada

Update Spring 2016

Abstract

Couples in long distance relationships 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. I designed and evaluated MyEyes, a First Person View video streaming system 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). I compared the three different views with 12 pairs of couple to explore the effect on social presence and body ownership. My results showed: (1). Overlapped View was most preferred by couples and it provided strongest co-presence while Horizontal View provided the greatest mutual understanding. (2). Couples valued performing synchronized acts together and doing activities 'in' the remote location. I discussed design implications for future first person view video technologies including enhancing social presence and body ownership in each interface. Future designers should also investigate privacy concern when using the system in public and how to provide greater control of video streams.

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

This work is dedicated to my parents, Hongying and Xiaobin. Thank you for raising me and providing for me the best that you can. "No matter how far and high the kite goes, its tethers are always tied to the flyer's hands."

Acknowledgements

First and foremost, I want to thank my thesis committee member Dr. Chris Shaw and external examiner Dr. Scott Bateman for their kind suggestions on my thesis and defence. You helped me polish the work and raised it to a higher level.

I want to thank MITACS Globalink for providing me with the precious internship opportunity and fellowship to open my eyes to research in Canada. I also want to thank NSERC for funding my research project and sponsoring my travel to academic conferences.

To my awesome advisor Carman, I could not thank you enough for all of your guidance and suggestions in both research and life. Thanks for being the “magic brush” for all my research projects. I would have been unable to accomplish two full papers, six extended abstracts and one workshop paper in my master’s without your help. Also, I want to thank you for giving me the freedom to explore what I might like to do when I decided to take an internship with Amazon. I still recall our very first meeting about “jar, sand and stone”. That was the most important lesson that I have learned about life. Thank you for spending time on more than one thousand emails exchanged and countless meetings (and live thesis-editing in the air to Denver!) to train me to be a scholar and a better man. I am so grateful to have a supervisor like you.

To Samarth, you are my best friend in grad school. Thank you for keeping me motivated and for always being someone who is super smart and hard-working. We cooperated in the coolest projects and discussed so many futuristic ideas despite our cultural differences. You were always there for me when I needed help. I will forever cherish our friendship and celebrate the good times we shared together.

To all the cLab superheroes: Yasamin, Azadeh, Lillian, Carolyn, Stephanie and Brennan, working with all of you was just so fun! I will remember all the laughs we enjoyed in lab meetings. You guys never made me feel out of place even though I came to Canada fresh-off-the-boat. Special thanks to Carolyn for the advice, roasted ribs, pies, and “Ray, get a fancy one!”.

To Jake, we had a lot fun times together (both online and offline). I am glad to have a friend like you since the very beginning of my Canadian journey back in 2014. To my college friend Yangyang, thank for helping me with your exquisite software development skills and warmhearted encouragements.

To all of the co-authors and colleagues that I am indebted to, including Bernhard Riecke, Alissa Antle, Tony Tang, Lyn Bartram, Thecla Schiphorst, Henry Lo, John Tang, Emily Cramer, Brendan Matkin, Song Qi, and all the other people who have helped and supported me, I will not forget your kindness. Thank you.

To all the SIAT Chinese gang, especially Jianyu, Yuhang, Junwei, Yuyao and Min, thank you for all the tasty food, love and support. 感谢你们！

I also want to thank my parents-in-law Cathy and Wenchun and my grandmother-in-law Ruiying for caring for me. I am so lucky to have such a great family!

And there is my wife, Lina, you have been inspiring me, supporting me and loving me since high school despite the geographical distance between us. “Absence makes the heart grow fonder.” Thank you for your constant understanding and patience. I can't wait to be with you for our next journey.

Publications

Materials, ideas, and figures from this thesis have appeared previously in the following publications.

Rui Pan, Samarth Singhal, Bernhard E. Riecke, Emily Cramer, and Carman Neustaedter. 2017. “MyEyes”: The Design and Evaluation of First Person View Video Streaming for Long-Distance Couples. In *Proceedings of the 2017 Conference on Designing Interactive Systems* (DIS ’17), 135–146. https://doi.org/10.1145/3064663.3064671

Table of Contents

List of Tables

List of Figures

List of Acronyms

CMC	Computer Mediated Communication
FPV	First Person View
HCI	Human Computer Interaction
HMD	Head Mounted Display
LDR	Long Distance Relationships
RHI	Rubber Hand Illusion

Chapter 1. Introduction

This work is initially motivated by my personal experience – being in a long distance relationship (LDR) with my wife for several years. I have been using FaceTime to video chat with my wife frequently but it is difficult for me to feel very close to her. Once I interviewed and studied many couples who had the similar experience, I started to understand the difficulty of communication over distance for couples who want to maintain a strong relationship. This led me to explore the special needs of couples when using Computer-Mediated Communication (CMC) tools such as video chat software for fostering communication. Although video chat systems such as Skype and FaceTime are widely adopted by couples for conversation in LDRs, they are typically limited in face-to-face style (e.g. to see each other's face and to chat as if they are talking in person). I want to have a new video chat experience that can help couples feel more like they are with each other over distance.

Now imagine a new video chat system that supports first person view sharing. Couples can use the system to exchange what they see from their eyes and interact within the partner's view. They can have the feeling of living in the partner's body and share a touch through a virtual visual illusion within the system. LDRs can also use the system to have dinner or go to a concert 'together' in their daily life. Hence, it becomes novel and fun for LDRs to strengthen their relationship in distributed settings. Designing and evaluating such a system is the main focus on my thesis.

1.1. Background

Long Distance Relationships (LDRs) involve couples who are geographically separated. LDRs are increasingly common due to various reasons such as education, work and travel (Manusov, 2006; Stafford & Canary, 1991). Just like collocated couples, relationship maintenance is an important part of LDRs and a lack of maintenance can

deteriorate their relationship (Stafford, Merolla, & Castle, 2006). Common activities for relationship maintenance includes being with one's partner, communicating with them, and empathizing (Stafford et al., 2006). Relationship maintenance is hard to achieve when people are separated by distance because of their lack of communication opportunities; thus, many couples in LDRs rely on Computer-Mediated Communication (CMC) tools such as video chat for mediating closeness (Neustaedter & Greenberg, 2012). 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 (Inkpen, Taylor, Junuzovic, Tang, & Venolia, 2013; Massimi & Neustaedter, 2014; Neustaedter & Greenberg, 2012). Neustaedter and Greenberg systematically studied the usage pattern of LDRs using video communication software and they found some couples like to share activities together over video chat (e.g., eating, watching movies, parallel working) (Neustaedter & Greenberg, 2012). Yet the experience can be limiting since partners lack an empathetic perspective of sharing video and are not able to touch one another (Neustaedter & Greenberg, 2012). Based on these limitations, the goal of my thesis is to explore the design of richer video communication mediums that might allow LDR couples to more deeply immerse themselves in their partners' remote location to feel like they are with their partner at the same place.

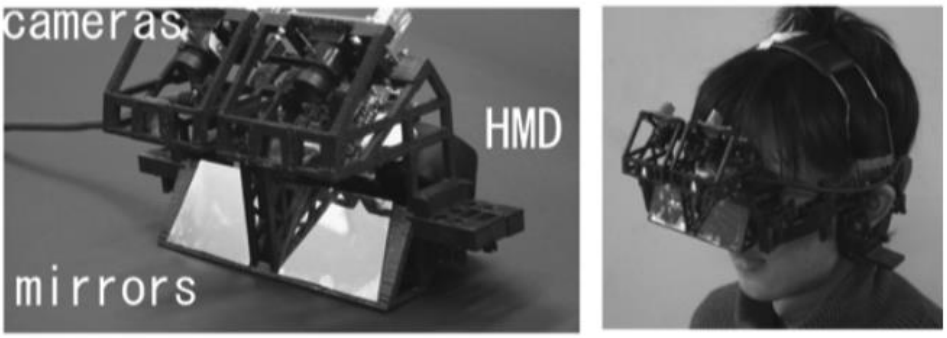

Figure 1.1 A FPV system with head mounted display
Source: *Publication* (Kawasaki, Iizuka, Okamoto, Ando & Maeda, 2010)

As one of the trends in new video chatting experiences, first person view (FPV) sharing (or first person video sharing) systems utilize head-mounted displays or mobile devices to provide a feeling of seeing from another person's eyes (Kasahara, Ando,

Suganuma, & Rekimoto, 2016; Kawasaki, Iizuka, Okamoto, Ando, & Maeda, 2010; Kuzuoka, 1992; Kuzuoka, Kosuge, & Tanaka, 1994). Figure 1.1 shows an example of FPV system by utilizing head mounted displays (HMDs). Existing systems have revealed that FPVs are suitable for movement synchronization in distributed settings (Iizuka, Kondo, Kawasaki, Ando, & Maeda, 2011). Kasahara et al. summarized the advantages of a parallel FPV system that (1) FPV systems help build understanding and decision making from multiple people; and (2) FPV systems help users share embodiment and spatial awareness in distributed setting. (Kasahara et al., 2016). Other researchers focus on the effectiveness and efficiency of the movement synchronization of FPV systems (Iizuka et al., 2011; Kawasaki et al., 2010). These findings are promising for collaboration over distance and remote skill training, however, few systems have focused on the communication needs of particular user groups such as LDRs. As LDRs have their own needs for communicating with each other (e.g. to feel intimate and stay close), I am curious to know whether the advantages of FPV systems could help LDRs to feel each other's physical embodiment, build understanding in distributed surroundings and feel more deeply immersed in the remote location, in order to feel a greater sense of 'being together'. 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 hardware and software should be designed in daily life, and how video should be displayed and what effects it will have on the couples.

Neuroscientist and phycologists have done the Rubber Hand Illusion (RHI) experiments to explore if we can 'swap body'. They used paintbrushes to stroke rubber hand and subject's hand simultaneously to provide an illusion of owning the rubber hand as part of the subject's body where they found the matching between visual perception and tactile sensation can result in the illusion of body ownership of others (Botvinick & Cohen, 1998; Costantini & Haggard, 2007). Social scientists further explored how such an illusion can be used for providing illusory body ownership of an outgroup such as person of different race, gender and age groups (Maister, Sebanz, Knoblich, & Tsakiris, 2013; Maister, Slater, Sanchez-Vives, & Tsakiris, 2015; Slater, Spanlang, Sanchez-Vives, & Blanke, 2010). Gender Swap experiment used similar illusion of owning another person's body to investigate gender and queer theories. However, in the HCI

community, little research has been done about how to utilize a similar illusion for long distance couples to feel the body of their partner in order to increase intimacy. By intimacy, I defined it as a private and close feeling and emotional connectedness between couples. In my thesis, I explore the FPV video chat systems in providing physical embodiment for couples even when they are apart.

1.2. Thesis Problems

My thesis explores the design and evaluation of first person view video (FPV) sharing systems. The overarching research problem in the thesis is: *we do not know how to design first person view video systems to help long-distance couples maintain their relationship and how they will use them.* More specifically, I have the following four research problems:

1. **We do not know how to design FPV systems for long distance couples.** Although many researchers have built FPV prototypes to help users see through other people's eyes (Kasahara et al., 2016; Kasahara & Rekimoto, 2015; Kawasaki et al., 2010) and found that FPV systems could help people feel physical embodiment and synchronize movements, yet very few systems have focused on supporting a specific group of users such as long distance couples. Meanwhile, existing systems typically require sophisticated technical designs and scripted testing environments. As long distance relationships have their specific needs (e.g. feel like being with the partner, be able to move around), we do not know yet how to design video systems to utilize the advantages of FPV to help long distance couples share new perspectives and feeling in video chatting.

2. **We do not know whether FPV systems can help long distance couples to feel social presence.** Social scientists have defined social presence as the 'feeling of being together in a same place' (Frank Biocca, Harms, & Burgoon, 2003). Feelings of being with one's partner in everyday life is important for relationship maintenance (Neustaedter & Greenberg, 2012). FPV systems can help users share first person perspectives but we do not

know whether FPV systems can create strong feeling of social presence for LDRs.

3. **We do not know whether FPV systems can help long distance couples gain body ownership remotely.** Neuroscientists and phycologists have found utilizing Rubber Hand Illusion can help users feel like they are owning another person's body (Botvinick & Cohen, 1998; IJsselsteijn, Kort, & Haans, 2006; Maister et al., 2015). HCI researchers have also found FPV systems can provide an illusion of living within another people's body (Kasahara et al., 2016). As physical touches are important for couples to mediate intimacy and they are difficult to be done when couples are in LDR (Singhal, Neustaedter, Ooi, Antle, & Matkin, 2017). I want to know if we could use the Rubber Hand Illusion to help couples feel like they are 'living in their partner's body' and virtually share physical touch experience to stay intimate when they are geographically separated.

4. **We do not know how long distance couples would use a FPV system to communicate and share activities.** As FPV systems provide new perspectives for users to share what they see, we do not know how long distance couples would use such system in everyday life to communicate and share activities compared to traditional video chat systems such as Skype and FaceTime. There is little research on how to utilize FPV systems for couples to move beyond "talking-head" settings (i.e. face-to-face chatting style).

1.3. Thesis Goals

Figure 1.2 My FPV system is made with cardboard goggle and smartphone

To address my research problems, the goal in my thesis is *to design and evaluate a FPV system for couples to maintain relationship over distance.* I break down the overarching goal into four sub-goals aligned with the aforementioned thesis problems.

1. **I will design a first person video streaming system that couples can use over distance.** I will create an affordable and easy-to-use design of a FPV system. This system will enable couples to share what they see without scripted testing environments or excessive technologic set-ups. Figure 1.2 shows the hardware used for building MyEyes.

2. **I will investigate which visual representation of video feed in a FPV system could help couples have stronger feelings of social presence.** I will design three different interfaces (Horizontal View, Split View and Overlapped View) in the system for representing visual information in a first person view video chat. I will also design a with-in group experiment to compare the three interfaces to investigate which interface can help participants gain more feeling of social presence by the Networked Minds Measure (F. Biocca, Harms, & Gregg, 2001) which is considered to be a valid and reliable measurement for social presence.

3. **I will investigate which visual representation of video feed in a FPV system could help couples have stronger feelings of body ownership:** I will compare the three interfaces mentioned in previous goal to explore which visual representation of video feed (Split View, Horizontal View or Overlapped View) can help couples gain stronger feelings of body ownership. This goal can help me better understand whether a FPV system can help couples transmit physical embodiment in video chatting.

4. **I will investigate how couples would use a FPV system to communicate and share activities:** When conducting the user study, I will ask participants to explore the usage of the system on their own and investigate what kind of activities they would like to do and how would they communicate with their partner when using a FPV system. I will also conduct interviews with them individually to learn how they would like to use the system in the future and what their concerns are when using it compared to traditional video chat systems like Skype.

1.4. Methodological Approach

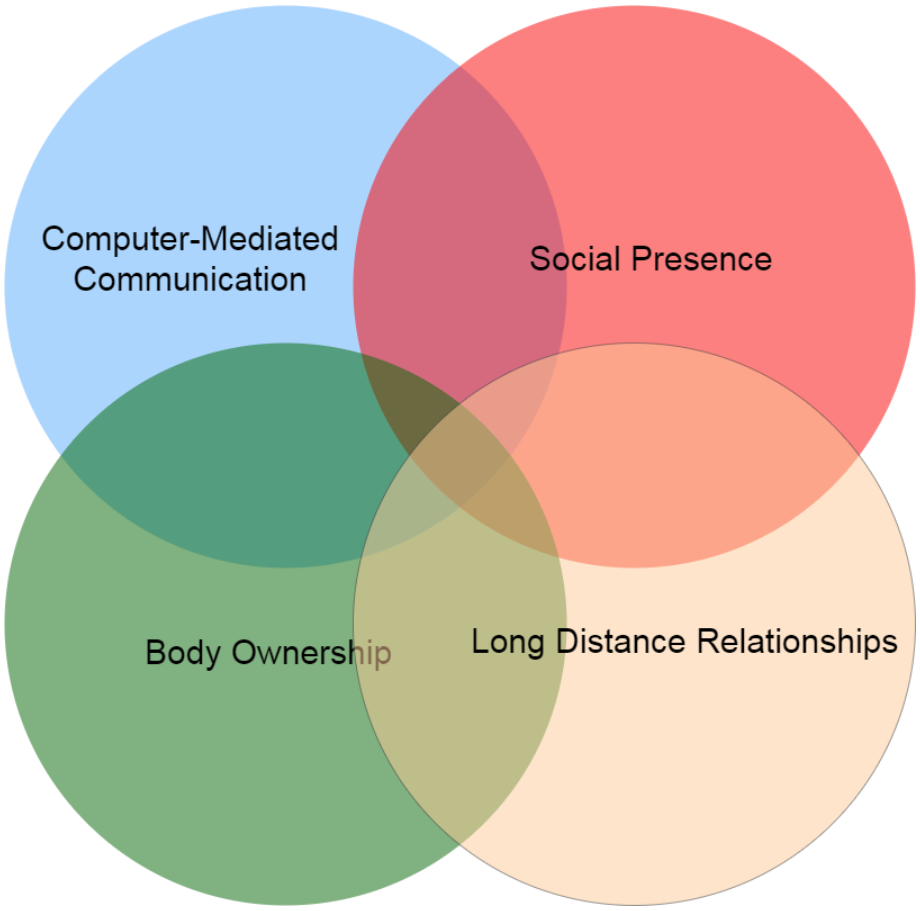

Figure 1.3 Domains of the research

My research focuses on designing and evaluating FPV systems for long distance couples to help them maintain their relationship. This topic involves interdisciplinary domains. Figure 1.3 shows the domains of the research of my thesis.

I start the thesis by finding a research problem in the disciplinary field of Human-Computer Interaction (HCI). Within HCI, I focus on Computer-Mediated Communication where researchers are designing and evaluating new systems to support people's communication. My targeted user group is long distance couples who face challenges in maintaining their relationships over distance. I include research background from social science, psychology and neuroscience. More specifically, I review the literature and propose research questions related to social presence and body ownership. These

disciplines help me gain new angles for looking into the communication solution for long distance couples.

I designed my system through iterative design methods. This includes sketching, brainstorming, drafting and prototyping. Once I had the initial version of the system working, I tried it with other researchers and revised the system based on their feedback. I also ran a pilot study with a pair of couple to test my systems in a realistic experimental environment and improved the system based on the outcome of the pilot study.

I designed a within-subject mixed-method experiment. A within-subject experiment is an experimental design in which the same group of participants are tested in different conditions (A. Field & Hole, 2002). Within-subject experiments are considered as an efficient design if researchers have a limited amount of participants (A. Field & Hole, 2002). The main weakness of within-subject experiment is 'carryover effects', in which the performance of a participant in a condition may have effect on the performance in other conditions (A. Field & Hole, 2002). To eliminate the carryover effects of within-group study, I counterbalance the order of using different interfaces and make sure each order has been tested twice. The mixed method study contains quantitative and qualitative components. I added a quantitative measure as it helps researchers use statistics to test hypotheses to find relationships between variables (A. Field & Hole, 2002). Qualitative measure helps researchers to investigate the implicit connection and meanings of information in the form of sounds, words and videos (Patton, 1990). Hence, I design a semi-structured interview with open ended questions. These questions can help me explore the connection within participants' behavior and answer 'why' participants would do certain activities. With open-ended questions, I ask participants about the feelings of using my system and the impact on intimacy, communication and relationship maintenance. The findings of quantitative and qualitative results are discussed in Chapter 5.

1.5. Organizational Overview

In Chapter 2, I provide a literature review. I discuss the challenges of communication that long distance couples are facing and how they use CMC systems to

mediate closeness. Then I introduce existing FPV systems of other researchers. Lastly, I discuss the theory of social presence and body ownership.

In Chapter 3, I discuss the design of MyEyes, my first person video streaming system for long distance couples. I explain the design rationale of MyEyes and the reasons of choosing Horizontal View, Overlapped View and Split View as targeted interfaces to investigate. I cover the technical detail and provide imagined usage scenarios of couples using my system.

In Chapter 4, I discuss the methodology for a with-in group study that investigates the effect of different interface of a FPV system on social presence and body ownership for long distance couples and how would couple use such a system. The study contains qualitative and quantitative methods and tested with 24 participants (12 couples).

In Chapter 5, I discuss the results of the mixed-method study. The quantitative results include the comparison of Split View, Horizontal View and Overlapped View on the feeling of social presence and body ownership based on the questionnaire. The quantitative results include categorization of the activities seen in the study and concerns of privacy.

In Chapter 6, I discuss design implications for future FPV systems. I first summarize the results from Chapter 5 and discuss the trade-offs of FPV systems and different interfaces for presenting videos.

Chapter 2. Related Work

In this chapter, I review theories and system designs related to my work. First, I review the literature on long distance relationships and couples' communication patterns with Computer-Mediated Communication (CMC) tools. I also describe related system designs supporting communication for long distance couples'. Second, I review related work of first-person video sharing systems, including different kinds of visual representations of video feeds designed by other researchers. Third, I review theories of social presence and body ownership, which form the basis for the study evaluation in my thesis.

2.1. Long Distance Couples and Technology

In this section, I introduce the definition of Long Distance Relationships and summarize their communication pattern. I also describe three trends in HCI research that aim to help couples maintain strong relationships over distance.

2.1.1. Long Distance Couples in Contemporary Society

Long distance relationships (LDRs) involve couples who expect to live together but are unable to do so due to geographical separation (Stafford, 2004). A large body of research from social scientists studied how couples maintain their relationship when they are separated. Long distance couples are very common nowadays because of job opportunities, education and travel (Stafford, 2004). Reports have found that 75% of college students have been involved in a LDR (Stafford et al., 2006). Despite the large amount of long distance couples in contemporary society, maintaining a relationship is difficult due to geographical constraints. For example, two-thirds of college students believed a LDR would not endure (Stafford et al., 2006) and many couples terminated

their relationship when they became geographically close after a long distance relationship (Stafford et al., 2006).

Couples need regular activities to maintain their relationship or the relationship will deteriorate (Stafford & Canary, 1991). Stafford and Canary studied the maintenance strategies of romantic dyads in terms of relationship type, gender and relational characteristics (Stafford & Canary, 1991). The analysis of their questionnaires revealed that five factors are important in maintenance activities: positivity (e.g., avoiding conflicts, having enjoyable interactions), openness (e.g., disclosing thoughts, sharing feeling), assurances (e.g., expressing love and faithfulness), tasks (e.g., sharing tasks and responsibility) and networks (e.g., spending time with common friends). However, for long distance couples, these activities are difficult to achieve.

A factor leading to the difficulty for couples (both collocated and distance-separated) to maintain their relationship is that they are unable to accept the inevitable shortcomings of their partner (Karney & Bradbury, 1995). The Vulnerability-Stress-Adaptation Model of Marriage (Karney & Bradbury, 1995) depicts the adaptive process of marriage satisfaction which contains understanding a spouse's vulnerabilities (e.g., personal shortcomings, childhood experiences). In LDRs, couples tend to idealize their relationship and avoid conflicts (Stafford et al., 2006). When they became geographically close, vulnerability issues are more likely to ruin the relationship because the "good image" of the spouse may not be reliable in collocated life. The 'quixotic idealization' of their relationship when they are apart and the loss of trust upon reunion make relationship maintenance for long distance couples more difficult (Stafford et al., 2006).

2.1.2. Computer Mediated Communications for LDR

Couples in LDRs are seeking ways to better connect with their partner. In Dainton and Aylor's study of 114 participants in LDRs, they investigated communication channels in association with relationship maintenance (Dainton & Aylor, 2002). The results showed that face-to-face communications could lead to positive relationship maintenance. They also found that the Internet could help long distance couples build trust between partners.

While couples in LDRs rely on traditional communication tools such as the telephone and letters, they also utilize computer-mediated communication tools to overcome their physical separation. A study of LDRs using video chat (Neustaedter & Greenberg, 2012) describes the routines couples have for communicating over distance. The authors conducted semi-structured interviews with 14 participants in LDRs. First, they found that couples highly value seeing their partner and sometimes use video chat. This allows them to feel emotionally closer with each other. The demeanor (such as looking tired and exhausted) can be seen by LDR couples, which helps partners empathize with each other. Also, most of the participants used video chat technology to check if the partner was available. The researchers noticed that time zone difference has an impact on the timing and planning of the video calls. Second, doing parallel and shared activities over video chat was very common. This includes parallel activities—i.e. doing one's own things while the video link is on—and shared activities—i.e. sharing activities via video chat such as watching TV and having a meal together. Third, the paper compared other CMC tools including text messaging and emails with video chatting. It revealed that participants perceived video chat to provide a higher level of connection than other CMC tools because it enabled users to see the partner while being apart. Despite the advantages of video chat, they also found some shortcomings with existing video chat systems (e.g., Skype), including the lack of mobility and support for conversing during shared and independent activities. This implied that couples value autonomy when using the CMC systems.

There is a great body of research related to new designs of CMC tools to help couples stay connected. Among these designs, I found that there were three important trends for designing for long distance couples. First, a lot of system designs utilize tangibility to support playful interactions. For example, WearLove (Joi et al., 2015) is a wearable device for couples to stay connected through a tree-planning game. WearLove consists of a wristband with touch pad where users can tap and show digital images like heart shapes. The researchers also designed a mobile game that uses the growth of a virtual tree to symbolize the relationship. Couples need to periodically interact with each other using the wristband to 'take care' of the tree. The design shows an example of using affective communication through a playful interaction to maintain a relationship.

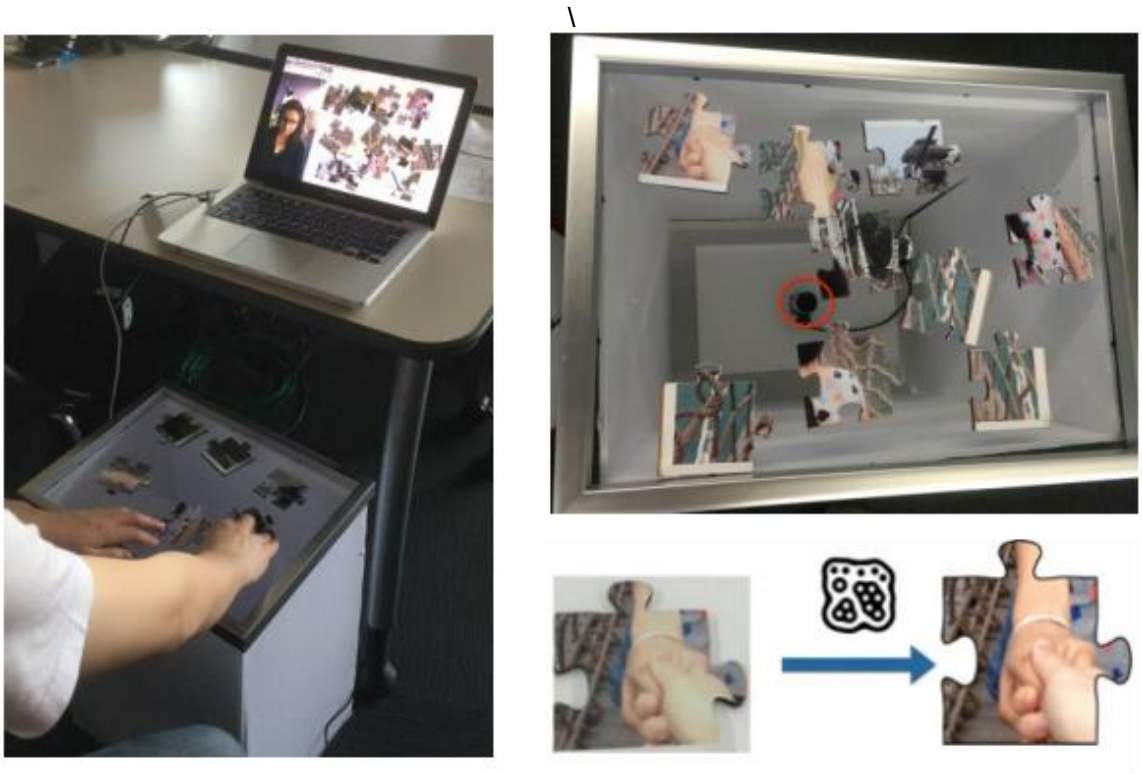

Figure 2.1 A tangible jigsaw puzzle game system supporting the play for long distance couples
Source: *Publication* (Pan et al., 2017)

Pan et al. created a table top tangible jigsaw puzzle for long distance couples to play 'together' virtually where partners manipulated his/her own puzzle pieces (Pan et al., 2017). Digital images of the puzzle pieces were shown on each partner's screen to show the movement on both sides. Couples needed to collaborate together to complete a whole digital puzzle over distance (Figure 2.1). They used fiducial markers for the mapping between physical pieces and digital contents.

Gooch and Watts explored the design of systems to support touch and hand holding over distance (Gooch & Watts, 2011, 2012). Again, participants enjoyed a sense of personalization and playfulness (Gooch & Watts, 2012). They also suggest designing for openness and flexibility (Gooch & Watts, 2011). YourGlove could send signals to a partner's hand to gently contract the hand for a hand-holding feeling. Alternatively, HotHands and HotMits used heat as sensory medium to simulate hand-holding. Their exploratory study revealed that couples valued tangibility in simulated co-located behaviors.

Similarly, Flex-N-Feel is an emotive glove that transmits vibrotactile interactions over distance (Singhal et al., 2017). Flex-N-Feel used a pair of interconnected gloves to allow couples to share a sense of touch. It consists of a 'Flex' glove and a 'Feel' glove. The user of the Flex glove can bend a finger to trigger a vibration on that finger of the other person. On the other hand, the user of Feel glove feels the vibration on his or her finger. Thus, transmission is asymmetric. Couples enjoyed the ability to create playful experiences with the prototype.

Overall, the aforementioned prototypes suggest that playful interactions and simulated physical co-presence are important for relationship maintenance.

Second, researchers have used artefacts from everyday life as a medium to express empathy and affection. For example, the BreathingFrame (Kim, Park, & Nam, 2015) was an inflatable photo frame that enabled couples to feel emotional connectedness by delivering a breathing signal to an inflatable surface. LumiTouch (Chang, Resner, Koerner, Wang, & Ishii, 2001) used photo frames as the medium for emotional communication. A similar idea is Lover's Cups (Chung, Lee, & Selker, 2006), in which couples shared affection through drinking behaviors, given that people feel more comfortable and intimate when they are sharing daily activities such as eating and drinking together (Chung et al., 2006). The designers suggest that although Lover's Cups could not replace traditional forms of communication such as video chat and text messaging, it provided new channels to complement the more traditional means of communication. This could help improve connections. The main message delivered by

these designs is that we can create technology using everyday artefacts or easy-to-use tools for sharing daily activities as a means for couples to stay connected.

Third, new video technologies have been designed to support versatile usage scenarios with video communications for long distance couples or long distance family members. These contain new technological improvements and user studies on new usage scenarios. For example, a technology probe called In Your Eyes used smartphones with Skype in auto-answer mode and placed it in partners' shirt pocket to provide an 'anytime, anywhere' video chat experience (Baishya & Neustaedter, 2017). It allowed partners to spontaneously interact with one another. A corresponding study revealed that the prototype can support new scenarios of using video technology to connect each other to feel closer while for some couples it infringed on each other's autonomy and privacy. They had two pairs of participants for a long-term study (a month). One couple provided positive feedback to In Your Eyes and found anytime anywhere connection beneficial for relationship maintenance. On the other hand, the other couple found it intrusive and problematic, especially when the couple valued less frequent connection and solitude.

Figure 2.2 The rule-based interface of Streamer.Space, the toolkit for creating context-aware mobile video streaming apps

Source: *Publication* (Pan and Neustaedter 2017)

Pan and Neustaedter created a toolkit called Streamer.Space to enable contextual information in video streaming (Pan & Neustaedter, 2017). Long distance couples can create customized video chat apps to have flexible control of privacy based on contextual information (e.g., stop streaming when I am within a certain location range). They provided an easy-to-use rule-based interface (Figure 2.2) and trigger-action logic for accessing video frames. The toolkit shows new usage scenarios for video communications such as sharing outdoor activities like hikes or bicycle rides.

Experiences2Go is a prototype which consists of camcorder, tripod and networked slate (Inkpen et al., 2013). They built virtual drivers to embed the images from the front-facing camera of the slate into the camcorder's recording. The researchers compared the prototype and traditional way of video streaming (Skype on iPad) with nine families. The results revealed that mobility, especially hands-free mobility is important when sharing outdoor activities. Participants valued seeing both people and activity at the same time as well as flexible control of the camera's panning and zooming (Inkpen et al., 2013).

These new video technologies provide insights for my video system design. Although existing video tools help distance-separated families and couples stay connected, they value flexibility and autonomy in controlling the video feed. Also, users are interested in seeing video in novel representation styles such as picture-in-picture. My system could compare different interfaces of displaying images to explore user preferences.

In summary, the three trends of Computer Mediated Communication systems for LDRs show the importance and different ideas of supporting couples to stay connected with the help of modern technological systems. The literature revealed many important implications for my system design and evaluation. I learnt that while existing video chatting systems such as Skype and FaceTime provide a means for couples to stay connected, even if they are geographically separated, couples want to have more flexibility in sharing activities via video links. More specifically, results show that couples highly value seeing their partner and sometimes use video chat to experience a sense of 'shared living' together. Yet existing video chat systems (e.g., Skype) lacked mobility and support for conversing during shared and independent activities. This shows there is a need for new designs of video chat systems. I also learnt from the design of CMC tools of other HCI researchers aiming to help couples to stay connected. I found connectedness and playful interactions were recurring themes amongst communication systems designed for LDR couples. This suggests designing for playfulness and flexibility. Existing studies on new technology probes also revealed that privacy concerns and autonomy are two prominent factors that need to be considered when designing new technologies.

2.2. First Person View Video Sharing

In this section, I introduce the related work on First Person View Video sharing systems. First, I describe existing system designs of FPV video sharing systems and summarize the advantages. Second, I describe different interfaces and visual representations of FPV video sharing systems.

2.2.1. First Person View Video Sharing Systems

First person view (FPV) video sharing systems utilize devices like Head Mounted Display (HMDs) to provide a feeling of seeing from another person's eyes (Kasahara et al., 2016; Kawasaki et al., 2010; Kuzuoka, 1992; Kuzuoka et al., 1994). The key difference between FPV video systems and existing face-to-face video chat systems such as Skype and FaceTime is that face-to-face video chat systems focus on providing a sense of physical co-presence, while FPV systems provide a broader perspective and immersive feeling of looking through another person's eyes. Researchers have studied FPVs in collocated collaboration and skill transition (Chua et al., 2003, p.; Kasahara et al., 2016; Kawasaki et al., 2010) and found FPVs to be valuable for enabling users to see from a remote perspective and create a physical embodiment in distributed spaces (Kasahara et al., 2016). For example, Kasahara et al. (Kasahara et al., 2016) 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 that 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 (Kasahara et al., 2016). Yet people sometimes lost their own sense of embodiment because they became overly focused on their partners' first person views (Kasahara et al., 2016).

2.2.2. Interfaces of FPV systems

There are some different interface designs of FPV systems. Studies on these

interfaces reveal that the visual representation of the video in FPV systems has a large impact on users' experience. Many designs focus on providing a 360-degree perspective. For example, JackIn Head (Kasahara & Rekimoto, 2015) is an omnidirectional head mounted camera that captures 360-degree images. It supports an asymmetric immersive video sharing style. In fact, the designers called it a 'Ghost-Body' mode where Body is the user who captures the image and the Ghost is the user who watches the video streams.

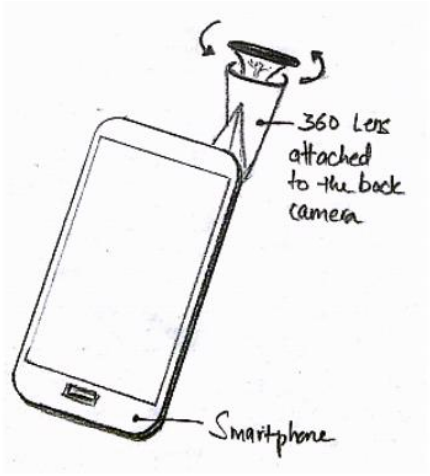

Figure 2.3 The hardware design of BeWithMe
Source: *Publication* (Singhal and Neustaedter 2017)

Similarly, BeWithMe (Figure 2.3) utilizes Google Cardboard and a hyperboloidal lens to provide an immersive telepresence for long distance couples (Singhal and Neustaedter 2017). Although both BeWithMe and JackInHead provide omnidirectional views when video streaming, BeWithMe uses simple and affordable tools and it can support symmetric usage where both users can stream and see at same time. As Kasahara et al. compared asymmetric and symmetric video first person streaming, they found that the asymmetric video stream may prevent users from transitioning between the roles of the 'watcher' and 'streamer' while symmetric shared views can extend perspectives of both the remote and local side (Kasahara et al., 2016).

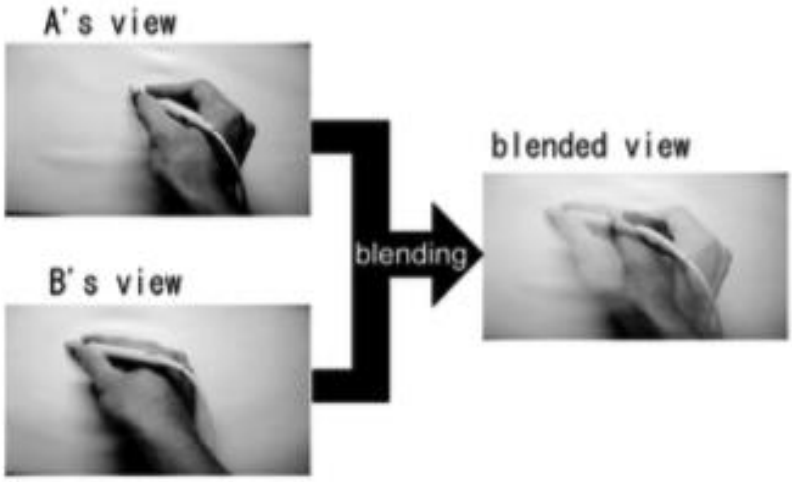

Figure 2.4 The blended view of a FPV system design
Source: *Publication* (Kawasaki, Iizuka, Okamoto, Ando & Maeda, 2010)

Some other researchers focus on how the image from different sides should be shown on the screen inside a head mounted display. Kasahara et al. proposed a parallel view for multiple users (Kasahara et al., 2016). This interface displays images from different users individually and has a clear boundary among images. Iizuka et al. proposed a 'blended view' (Figure 2.4) where images of the remote and local side merge into the same frame (Iizuka et al., 2011). In their study, they also compared the blended view with a swapping view where each user can only see the view of remote user (Kawasaki et al., 2010). They found the blended view requires less time for synchronizing movements but it was more confusing for participants than the swapping view. They suggest that first person view systems could be beneficial in skill transitions and training while the coupling styles of the video have an impact on the experience of users.

The related work of existing FPV video systems and their interface designs provides inspirations for the design of MyEyes. While the existing systems have provided immersive video chatting experiences to different extents, the ability to support specific relationships (such as long distance couples) has not been evaluated. In this thesis, I am interested to know whether the advantages of symmetric FPV video exchange could help LDRs to feel a sense of being together. Also, the ability of losing and restoring someone's physical embodiment has not been studied yet to help couples

feel a sense of ‘virtual touch’ over distance. This gives rise to follow-up research questions about the impact of different visual representations of video feeds on the feeling of social presence and body ownership of couples. On the other hand, most of the aforementioned FPV systems require sophisticated hardware designs or equipment and scripted testing environments. How to design an easy-to-use prototype for couples’ everyday activities still remains unknown.

2.3. Social Presence

People now rely on mediums to communicate with other people. This ‘medium’ can be a telephone, a video conferencing system or other CMC tools. Social scientists and HCI researchers have been studying the impact of feelings of being with another for decades and developing theories of social presence. Short et al. started to use the term *social presence* in telecommunication in 1976 (Short, Williams, & Christie, 1976). In general, social presence can be defined as the sense of being with another in mediated environments to compare media interfaces and understand users’ behaviors (Frank Biocca et al., 2003). Biocca et al. summarized different measures of social presence in mediated environments and formed a robust theory of social presence in his journal paper (Frank Biocca et al., 2003). The paper provides a large amount of insights related to my interface design and evaluation. First, they emphasized the importance of social presence in evaluating interactive systems and collaborative tools. Second, they categorized varying definitions and measurements of social presence in different contexts. Third, they provided examples of the criteria and scope when measuring social presence with a technological question. I describe the most pertinent of these to my research next.

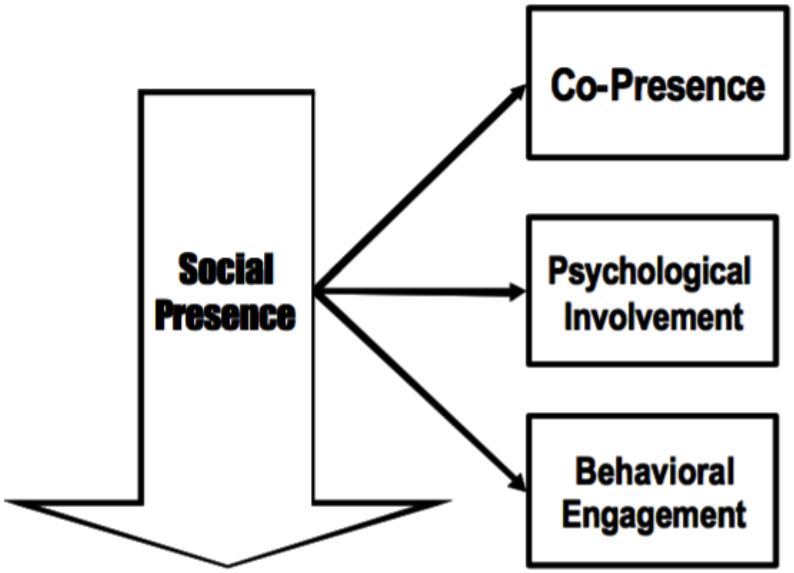

Figure 2.5 Three components of social presence in The Networked Minds Measure

Source: *Publication* (Biocca et al., 2001)

As Biocca et al pointed out, there are numerous measurements of social presence and the measurement has to depend on the conceptualization of social presence in a particular context (Frank Biocca et al., 2003). Reviewing different measurements of social presence is necessary to help design my study. A common approach used to measurements social presence is 'subject self-report' (F. Biocca et al., 2001; Frank Biocca et al., 2003; Nowak & Biocca, 2003). A measurement called The Networked Minds Measure (F. Biocca et al., 2001) breaks down social presence into three sub-categories: Co-Presence, Psychological Involvement and Behavioral Engagement (Figure 2.5):

1. *Co-Presence* represents the degree to which one feels like he or she is not alone (Frank Biocca, Harms, & Gregg, 2001). The measurement of co-presence contains factors related to the feeling of isolation (e.g., "I feel alone") and mutual awareness (e.g., "I can easily notice my partner").

2. *Psychological Involvement* represents the degree to which "the observer allocates focal attention to the other, empathically senses or responds to the emotional states

of the other, and believes that he/she has in-sight into the intentions, motivation, and thoughts of the other." (p2, F. Biocca et al., 2001). The measurement of psychological involvement contains the factors of empathy (e.g., "I was influenced by my partner's mood"), and mutual understanding (e.g., "I can understand what my partner was doing and what he/she meant.").

3. *Behavioral Engagement* represents the independence, connectedness and responsiveness of one's actions and behaviors (Frank Biocca et al., 2001). The measurement contains behavioral interdependence (e.g., "My action was reposing to my partner's"), mutual assistance (e.g., "We needed to help each other to complete a task") and dependent action (e.g., "I could not act without my partner").

The Networked Minds Measure provides aspects that researchers need to consider when designing a subject self-report study. It has been shown to be a valid and reliable measurement of social presence when comparing different mediums or interfaces. The study by Harms and Biocca conceptualized and verified six dimensions of the Networked Minds Measure including co-presence, attentional allocation, perceived message understanding, perceived affective understanding, perceived affective interdependence and perceived behavioral interdependence (Harms & Biocca, 2004). These six dimensions were built on top of the three main categories of social presence used in my study. This shows social presence was not a monochrome term but a scientific theory which requires in-depth measurement on its compositions. Another important message emerging from The Networked Minds Measure is that these aforementioned sub-categories of the three main components of social presence can be sensitive to a task's properties (Frank Biocca et al., 2001). This indicates that researchers need to carefully select sub-categories to measure social presence depending on an experiment's tasks and research problems.

In the CMC literature, there are studies focusing on social presence as well. For example, the study on the emotive glove Flex-N-Feel utilizes open-ended questions and interviews to investigate how much couples feel they are 'with' their partner while sharing a virtual touching experience (Singhal et al., 2017). In the paper about JackIn Head, the

authors described their hypothesis on the social presence of ‘Body’ and ‘Ghost’ views when using The Networked Measure (Kasahara & Rekimoto, 2015).

The theories and measurements of social presence indicate the importance of studying social presence in mediated environments. My study is to evaluate a FPV video streaming system where couples use the system for mediating closeness. Thus, understanding the social presence that couples feel while using my system can provide an in-depth evaluation of the benefits of the system. As social presence is an important aspect of measuring mediating tools as well as users’ behaviors in mediated environments, there are different kind of measurements of social presence based on context. I picked The Networked Minds Measure as the overarching measurement in my study for social presence because it is proved to be a valid and reliable measurement when comparing different interfaces and mediums for people’s communication.

2.4. Body Ownership

Body ownership is the feeling that a body or body part is one’s own (Costantini & Haggard, 2007, p.; Tsakiris, 2010). Body representation consists of two significant factors, body schema and body image (Costantini & Haggard, 2007). Body schema is an internal standard built based on people’s sensory experiences. For example, we know how to use our hand to grab a bottle based on our proprioceptive experience in the past. Body image is the visual perception of body appearance (Costantini & Haggard, 2007). For example, looking at your hands indicates to you that your hands belong to you. In some circumstances, such as the Rubber Hand Illusion (Botvinick & Cohen, 1998), 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) (Ehrsson, Holmes, & Passingham, 2005; Petkova & Ehrsson, 2008). Figure 2.17 shows the experiment of the Rubber Hand Illusion where the researcher touches the real hand and rubber hand at the same time. The participants could feel he ‘owns’ the rubber hand at some point.

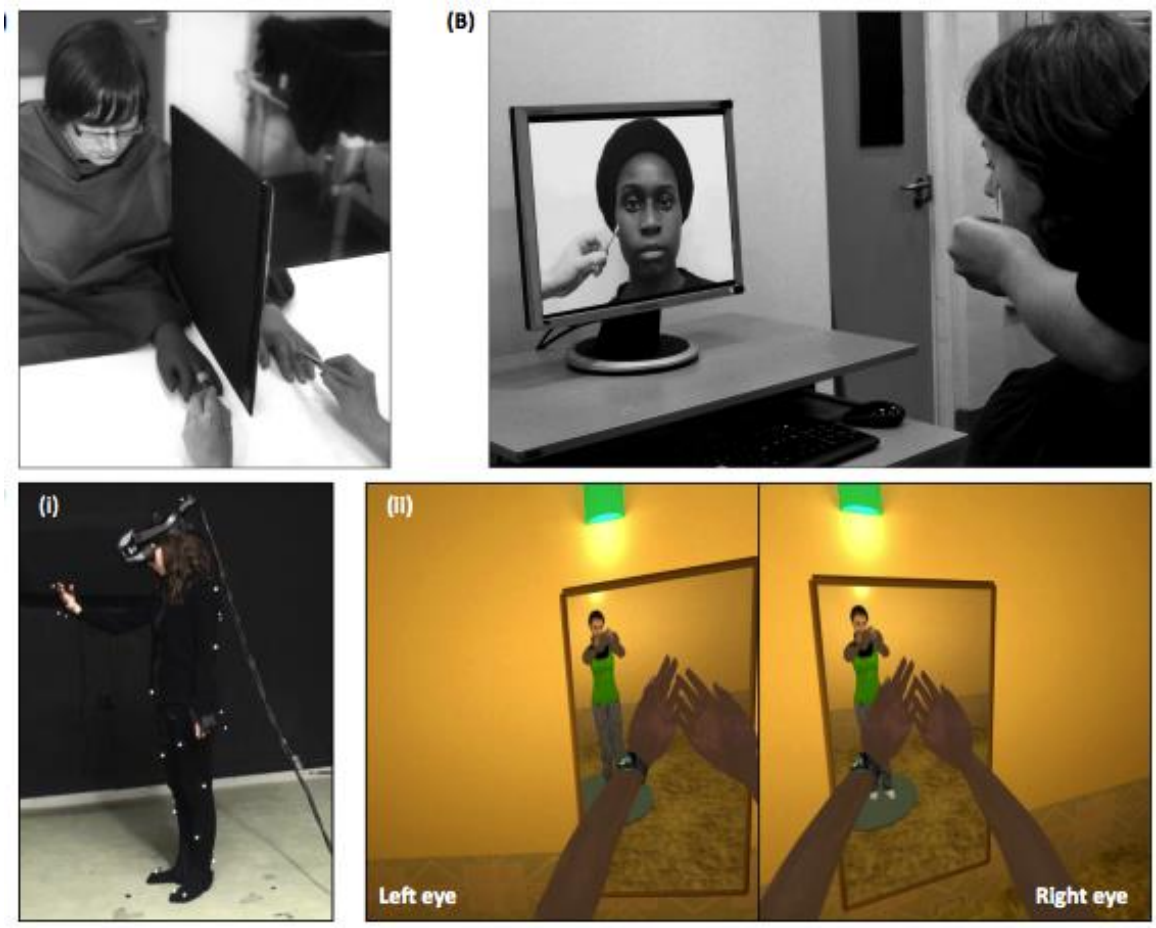

Figure 2.6 Researchers use virtual reality to experiment the transition of body ownership to another race
Source: *Publication* (Maister et al., 2015)

This can give rise to fascinating illusions of gender, race and age swapping (Maister et al., 2015; Maselli & Slater, 2013; Petkova & Ehrsson, 2008). A large amount of this research involves virtual reality. For example, Maister et al. investigated how we might be able to change an implicit social bias by changing body ownership to outgroups, people from another race, age group or opposite gender (Figure 2.6).

The related work on body ownership provides interesting possibilities. For example, we might be able to utilize the Rubber Hand Illusion to let users feel as if they can 'touch' their partners' hands in an effort to strengthen intimacy. From the books of Tiffany Field and Ashley Montagu, we know that touching is a strong emotional means of physical communications (T. Field, 2003; Montagu, 1971). The study of Flex-N-Feel also

revealed that couples were interested in being able to touch each other remotely and that touch could impact couples' feelings of intimacy (Singhal et al., 2017). However, it is difficult for people to exchange a 'real' physical touching experience without sophisticated telepresence robots or vibrotactile technologies. Hence, I want to investigate whether my prototype could simulate a feeling of physical touch by manipulating one's sense of body ownership when using FPV video streaming, and how could we design interfaces to provide the body ownership in video chatting.

The measurement of body ownership usually contains two parts: the objective measurement and the subjective measurement. A commonly used objective approach is to measure the width of the proprioceptive drift. Researchers used a ruler to compare the distance of strokes on a real hand with the baseline and the distance of strokes on a rubber hand with the baseline (Costantini & Haggard, 2007). The drift of the two types of distance can be used as a quantitative measure of body ownership (Botvinick & Cohen, 1998; Costantini & Haggard, 2007). Subjective measures use questionnaires with questions about feelings associated with one's hands. The questionnaires contain questions such as "I felt more hands", "I felt a larger hand" and "I felt the hand was moving" (Botvinick & Cohen, 1998; Ehrsson et al., 2005). For example, in Botvinick and Cohen's Rubber Hand Illusion experiment, they used a nine-item questionnaire as a subjective measure. Three measurements had significant tendency to positive responses. The three items were: 1.) "It seemed as if I were feeling the touch of the paintbrush in the location where I saw the rubber hand touched", 2.) "It seemed as though the touch I felt was caused by the paintbrush touching the rubber hand, and 3.) "I felt as if the rubber hand were my hand."(Botvinick & Cohen, 1998). The subjective measure provides an effective way of revealing the feeling of a rubber hand illusion. In my study, I should consider using a similar approach to get the subjective responses of participants.

2.5. Summary

In this chapter, I reviewed literature related to my research. Four main areas have been outlined as the background for designing and evaluating FPV systems for long distance couples. First, I described related work on long distance relationships

including the communication challenges that they face and the significance of relationship maintenance. Here, I covered examples of new video chat systems that “go beyond talking head settings” to provide more flexibility in video communications. Second, I introduced first person view video sharing technologies. I summarized the advantages of FPV systems used as novel CMC tools for fostering group collaboration and professional training. I also gave a few examples of FPV system designs. Third, I reviewed the theory of social presence including the definitions from social scientists and different measurements. Lastly, I introduced the theory of body ownership. I also included some typical experiments of exploring body ownership such as the Rubber Hand Illusion experiment.

In the next chapter, I will describe how I designed MyEyes and the design rationale.

Chapter 3. The Design of a First Person View Video System

In this Chapter, I describe the process of designing a first person view video system called MyEyes. I give a detailed design description of each iteration of the prototype and the interface design. I also include the design rationale that MyEyes is based on. In the last section, I give examples of how to use the system for long distance couples.

3.1. Design Goals and Motivation

The first research goal proposed in my thesis is: *"I will design a first person video streaming system that couples can use over distance."* The basic functionality in such a video system is to support couples sharing first person perspectives of seeing surroundings and doing activities. Compared to traditional video chat systems, the design challenge of FPV systems is that FPV video conferencing has typically required sophisticated and expensive equipment with pre-configured and scripted testing environments (e.g., Kasahara et al. 2016; Kasahara and Rekimoto 2015). One design goal was to see if I 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 (Neustaedter and Greenberg 2012); thus, portability and ease-of-use are critical factors for system design. In Chapter 2, I explained how couples sometimes need communication tools for mediating closeness. The related work also indicates that different interfaces in FPV video systems have effects on the experience. The goal of my design is to create feelings of being with one's partner and sharing a sense of touch over distance in FPV video chatting. .

I am eager to know what would happen if I gave couples the ‘power’ of seeing through their partner’s eyes in novel interfaces. Imagine a person who can see his/her surroundings while interacting with their partner at the same time. This motivated me to design MyEyes to investigate on users’ behaviors and communication patterns when using FPV video chat systems.

3.2. Early-Stage Design

The early-stage design of MyEyes contains hardware and software designs. In this section, I introduce the hardware used for MyEyes and software development process.

Figure 3.1 Two collocated friends are using Ghost Partner for sharing views
Source: *Photo* (Carman Neustaedter)

Figure 3.2 Users are trying to 'own' the other person's hand by switching left eye and right eye in Ghost Partner

Source: *Photo* (Bernhard Rieckie)

My lab colleague, Samarth Singhal, came up with the very first idea of a FPV video system called Ghost Partner. With Ghost Partner, users can share a split view with the other user. By switching one's view between his or her left and right eyes (closing one eye or the other), users can choose either local or remote views to focus on. Figure 3.1 and Figure 3.2 depict the scenario of two local users using Ghost Partner. When my lab mates tried to use Ghost Partner, they experienced an interesting illusion of 'living in the other person's body'. This created my interest for investigating body ownership with the novel video communication tool. However, the design of Ghost Partner contains only one interface which is the split view. I wanted to compare different interfaces so I redesigned Ghost Partner with two more interfaces and named it MyEyes.

Figure 3.3 MyEyes is made with cardboard goggles and smartphone

Figure 3.3 shows the hardware design of MyEyes. I used Unofficial Cardboard (a similar product of Google Cardboard) with a head strap and Android smartphone. I attached a piece of sponge on the backside of the cardboard's cap to provide more stability for smartphones. Two paper chips located on the side of the cardboard can be pinched to adjust the glass lenses inside the cardboard. I used Samsung S4 and Nexus 5 as the two interconnected smartphones as they have similar screen sizes (136.6 x 69.8mm and 137.9 x 69.2 mm). The weight and width of the two phones are also ideal for long-term usage with head straps (130g weight and 8mm width). With MyEyes, 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 the adjust lenses by pulling the 'ears' on the side of the cardboard.

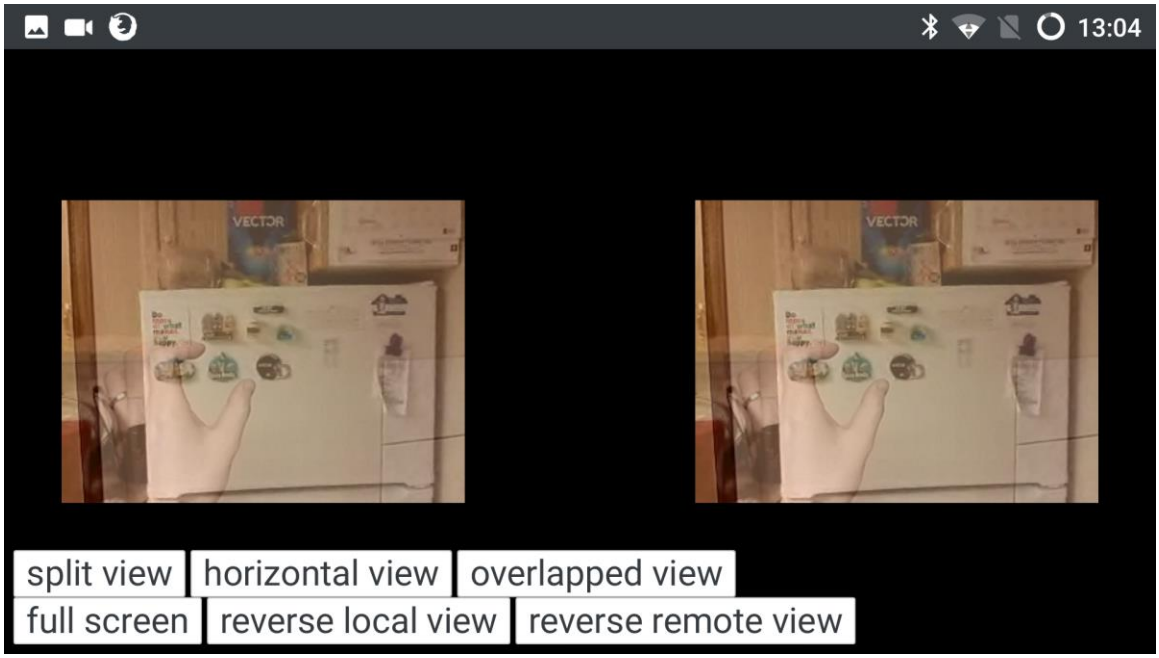

Figure 3.4 The Overlapped View shown on the phone screen. Here local and remote image are overlapped in a same frame

I designed two interfaces called ***Horizontal View*** and ***Overlapped View*** in MyEyes. Along with the ***Split View*** from Ghost Partner, I have three interfaces for representing visual information. Here I explain the rationale for choosing the three views:

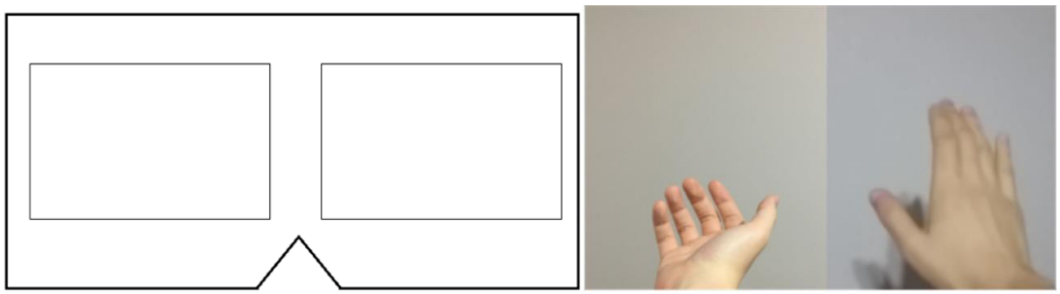

Figure 3.5 The Split View design (left) and the Split View for seeing

1. In **Split View** (Figure 3.5), 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. I included 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 (Corballis, 1995; Spence, Kingstone, Shore, & Gazzaniga, 2016). 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 I 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.

Figure 3.6 The Horizontal View design (left) and the Horizontal View for seeing

2. In **Horizontal View** (Figure 3.6), the local and remote video feeds are stacked vertically, one on top of the other. This is very similar to Parallel Eyes (Kasahara et al., 2016) 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 I 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 in FPV systems.

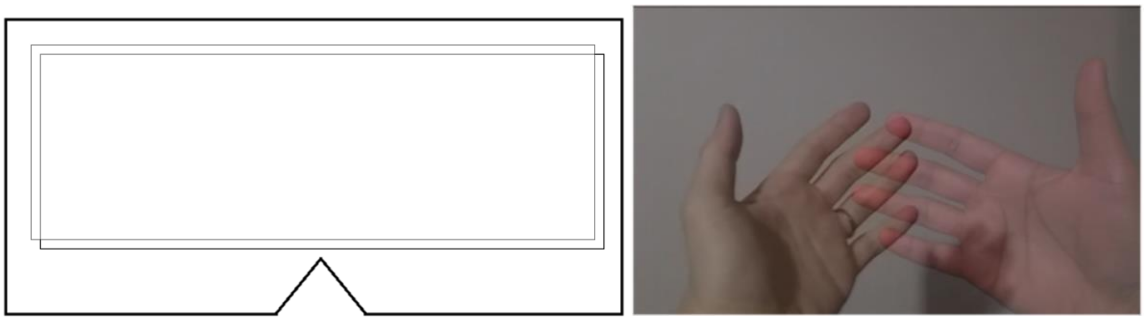

Figure 3.7 The Overlapped View design (left) and the Overlapped View for seeing

3. In **Overlapped View** (Figure 3.7), I merged two video feeds in the same frame by changing the transparency of two video frames (50% local video and 50% remote video), akin to the 'blended view' proposed by Iizuka et al (Iizuka et al., 2011). They found this visual coupling style required less effort when people tried to synchronize their movements. I wondered if we could use the advantage of this interface to simulate a 'physical touch' without sophisticated telepresence robots or vibrotactile technologies. The answer could provide a new solution to help LDRs interact, experience and bond with each other.The technology stack I choose for building MyEyes includes WebRTC, WebSocket, HTML5 API and JavaScript. Most of them are modern web development technologies. WebRTC is an open-sourced Real-Time Communications library. WebSocket is used for enabling socket data channel between clients on web browsers. The access to built-in cameras of smartphones is supported by HTML5 API and JavaScript. The three interfaces (Split View, Horizontal View and Overlapped View) are implemented using CSS (Cascading Style Sheets). In the early design, users needed to manually touch the button shown on the mobile screen to toggle different interface. When using, users entered the video chat app on their smartphones and then put MyEyes on their head with the head strap. Each view shows the perspective from viewpoint of another person's eyes. This makes them first person views.

3.3. Pilot Study

After finishing the first iteration of system design, I invited a pair of couple to test the out system as a pilot study. The goal of the pilot study was to examine the feasibility of the system in an experimental environment. There were three main issues exposed in the pilot study about my early design of MyEyes:

1. It was too difficult for participants to switch interface by themselves. I let the couple try all three interfaces but the process of switching interfaces was time-consuming. It required participants to take off the cardboard goggles, hit a button on the phone screen, put on the goggles and adjust their position and the lenses again every time. Given the limited capacity of a mobile phone's battery, the switching process can take a great amount of time unrelated to the experiment. I needed to design a new approach that could help participants switch the interfaces of MyEyes more easily.

2. The sound quality dramatically dropped when network was not stable. When participants talked via a built-in microphone, WebRTC transmits the voice data. However, participants experienced noise and sound interference when the Wi-Fi network was not stable. In severe situations, they could not even talk to or hear each other. This issue seriously affected the experiment. For the final prototype, I needed to work on optimizing the audio connection or consider alternative ways to complete experiments.

3. Researchers found it hard to obtain observational data without staying in the same study room. With the initial design of MyEyes, researchers had to stay in the same room with participants to guide them or help switch the interfaces. This slowed down the experimental process and created an observer effect to the study results. By observer effect, I am referring to the behaviors of participants may appear unnaturally when another person is standing by them. I needed to find solutions to let researchers collect observational data without staying in the same room as the participants.

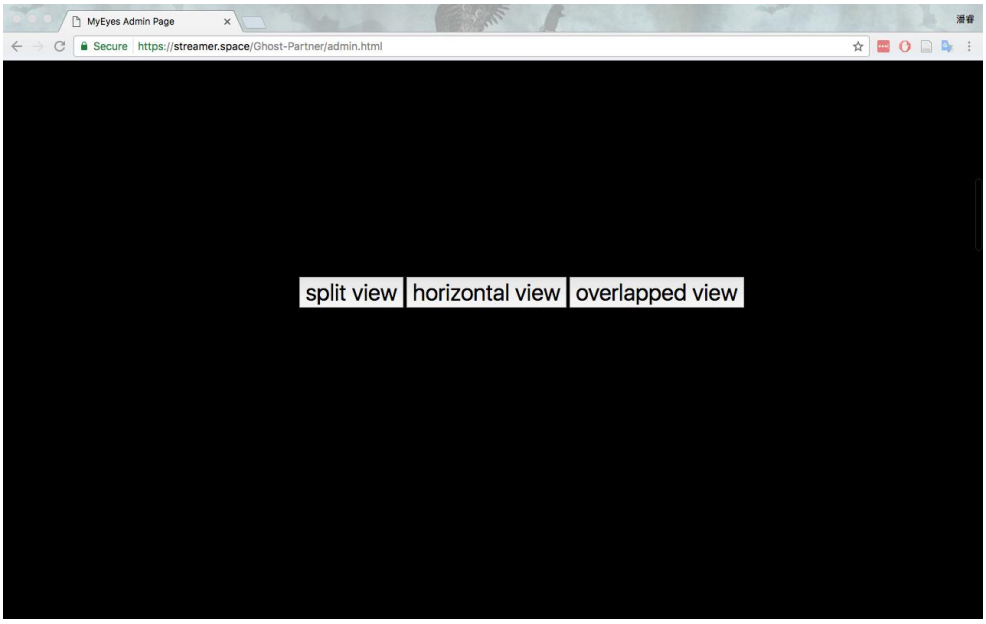

Figure 3.8 The webpage for the remote switch. Researchers can remotely switch interfaces of MyEyes by clicking the button on this page

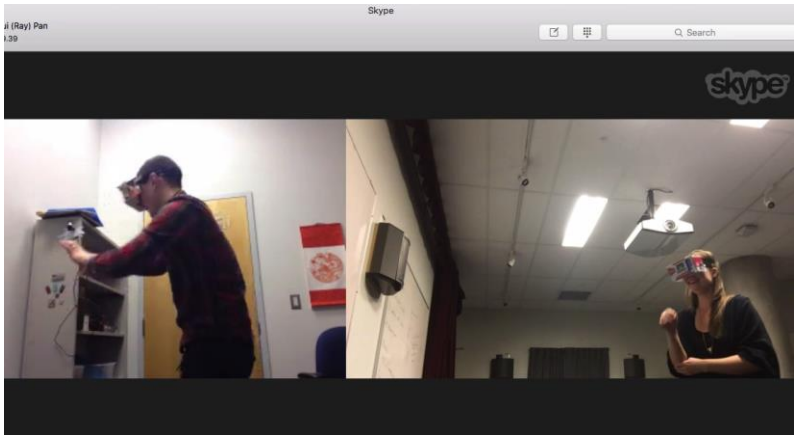

Figure 3.9 The screenshot of Skype capturing live ongoing in study rooms

3.4. Final Prototype

Considering the feedback from participants from the pilot study, I created the final prototype design of MyEyes.

First, I developed an online remote switch that allows researchers to change the interface of MyEyes by clicking buttons on a webpage. Thus, I would not have to enter the study rooms and have participants take the goggles on and off to switch the interface. Figure 3.8 shows the webpage for the remote switch. I imagined the switch could help reduce preparation time for the study as well as eliminate observer's effect.

Second, I placed an iPad with Skype for recording audio in the study room. This way the iPad could be used to transmit audio data between users. This helps solve the voice quality issue when the Wi-Fi network is not stable. Through a Skype group call, I could also observe and record the ongoing study in the rooms. Hence, I did not need to stay in the same room as the participants. I imagine this can also help reduce the observer's effect in observational data. Figure 3.9 shows a screenshot of the Skype group call when I was running my study.

3.5. Usage Scenarios

Based on my expectations. I illustrate the following four usage scenarios of couples using MyEyes as a part of their everyday life:

1. **Playing games together remotely:** couples could benefit from MyEyes by playing games together remotely. Because MyEyes contains three different interfaces, it could bring novelty to game sharing. Consider the following imagined usage scenario:

Amy and Aaron are college students and in relationships. They like playing Go (a Chinese board game with black and white stones) together. Amy went for an exchange program outside the country. They still play Go online using laptops but it never gives them a feeling of playing with the real person. One day they try MyEyes for video chatting. They start to play Go in the Overlapped View. The position of Amy's and Aaron's stones can be seen on each other's screen. They enjoy playing Go with MyEyes just like physically playing together.

2. **Share intimate acts:** the act of intimate touching can be hard to do when couples are geographical separated. By intimate touching I am referring to physical

touches needed for emotional and sexual satisfaction including handhold, hug and kiss. I imagine that MyEyes can be used to create virtual touching sensations by synchronizing movements and perceptions. Consider the following imagined usage scenario:

Henry and Helen have been long distance partners for many years. Sometimes they use Skype and FaceTime for cybersex. Henry finds the touching sensation from Helen is difficult to get by simply using face-to-face video chatting software because they watch the touch happen away from their body. They start to use MyEyes with Split View. Both Henry and Helen reach their arms out in front of them in Split View. It feels like they are owning the other person's arm because they see the partner's hand reaching out in front of their eyes. When they start to touch their shoulder, they can feel the physical touch but they 'see' that it is their partner who is touching the shoulder.

3. **Enjoying concerts remotely:** MyEyes provides the ability to see through another person's eyes. The feature can be used to share different activities such as a library visit, attending a concert or sightseeing. Consider the following imagined usage scenario:

Ben and Bella are music lovers. They have been in a relationship for many years but Ben is working outside the country for this year. Ben and Bella want to continue their common hobby by using MyEyes. When Bella goes to a musical in a theater, she puts on MyEyes and shares the live musical to Ben in Horizontal View. Ben can see both the live music and his own surroundings.

4. **Share outdoor activities:** Many video communication researchers have found that 'going outdoors' and 'going beyond talking-heads' are important trends in modern video chatting (Massimi & Neustaedter, 2014; Procyk, Neustaedter, Pang, Tang, & Judge, 2014). MyEyes can support users sharing outdoor activities in a first person view. Consider the following imagined usage scenario:

Ken and his wife Kelly go running every day, even when Ken travels to some other cities for client meeting. They used to make phone calls while walking or running outdoors. However, Kelly could not see what Ken was talking about because there was no image for her. They start to use MyEyes with the Horizontal View. While Ken is

running or walking with MyEyes, he can see his 3-year-old son having breakfast at home. Kelly is also able to enjoy the beautiful scenery when Ken runs by maple trees.

The four scenarios show the versatility of MyEyes and the variety of supported contexts. While these scenarios may not be fully realistic cases because of the capacity of the battery of phones, network quality and image stability, they demonstrate new possibilities brought by FPV video streaming like MyEyes.

3.6. Summary

In this Chapter, I described the design iterations of MyEyes, a FPV video sharing system. The chapter includes early design, pilot study and its feedback, final design and usage scenarios. The design rationale of the three interfaces that I chose for MyEyes is also included. MyEyes contains both hardware and software design. I used cardboard goggles, smartphones and head straps as the hardware components. For software design, I used web development technologies including WebRTC, WebSocket, HTML5, CSS and JavaScript for building video connection and interfaces. The pilot study exposed some technical issues of the early design and I improved the system accordingly to better serve a lab experiment. I will introduce the experiment design in the next Chapter.

Chapter 4. Methodology

In this chapter, I describe the methodology of how I studied and evaluated MyEyes, including the recruitment of participants, study methods, data collection and data analysis. I designed a with-in group study with qualitative and quantitative research methods. I recruited 12 pairs of couples to test and compare the three interfaces (Split View, Horizontal View and Overlapped View).

4.1. Study Goals

The goal of my 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. I also wanted to investigate how couples would like to use a FPV and what activities they would like to share over the system. I designed a repeated measures study with three tasks and an exploratory session.

4.2. Participants and Recruitment

I 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 Vancouver, Canada. Four pairs were married. Most of the 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. At the time of the recruitment, all participants were living in the same city. The age range was from 21–31 (M=25.83, SD=2.94). 11 couples were heterosexual, and one was homosexual (P19 and P20 were both female). The occupation of the participants included college students, designers, engineers, a sales person, and a logistics coordinator. Participants signed

consent forms prior to the study. Although couples were tested in pairs, they gave responses and were interviewed individually. Table 1 shows the demographic information including their age, gender, occupation, if they previously had motion sickness from using virtual reality systems and previous experience of virtual reality. Table 1 also includes the information about their relationship, including martial status, length of relationship, how long have they been in a LDR, how far apart they were from their partner when in the LDR, and usage patterns of existing video tools.

Table 1. Demographic information of participants

Participant No.	Couple No.	Married	Gender	Age	Length of Relationship	Been in LDR Before?	Distance	Used Skype/FaceTime Before?	Tried VR Before?	Motion Sickness before?	Occupation
1	Couple 1	Yes	Male	26	4 Years	3 Years	China - US	Yes, very frequently, every 2 days	Yes	No	Student
2			Female	27					Yes	No	Student
3	Couple 2	No	Male	28	4 Years	No	N/A	Used Skype only once.	Yes	Yes	Software Engineer
4			Female	28					Yes	No	Student
5	Couple 3	Yes	Male	28	6 Years	3 Years	Singapore - Canada	Skype, Viber, ooVoo	Yes	No	Engineer
6			Female	28					Yes	No	Student
7	Couple 4	No	Male	20	14 Months	No	N/A	Wechat/Facebook/Skype, everyday	Yes	No	Student, entrepreneur
8			Female	21					Yes	No	Student
9	Couple 5	No	Male	25	20 Months	No	N/A	FaceTime, maybe just two times	Yes	No	Part-time student, full time sales person
10			Female	24					No	N/A	Student
11	Couple 6	Yes	Male	31	9 Years	4 months	Mexico - Australia	> 3 times a week, Skype	Yes	No	Designer
12			Female	29					Yes	Sometimes	Student
13	Couple 7	No	Male	27	1 Years	6 months	Europe - Canada	Facebook Video Messenger, Daily	Yes	No	Electrician
14			Female	25					Yes	Yes, very easily	Student
15	Couple 8	Yes	Male	24	6 Years	Few months	China - Canada	Wechat everyday	No	N/A	Student
16			Female	25					No	N/A	Student
17	Couple 9	No	Male	27	1 Year	No	N/A	FaceTime, Weekly	No	N/A	Student
18			Female	23					No	No	Logistics Coordinator
19	Couple 10	No	Female	21	8 Months	2 months	Hong Kong - Vancouve	Skype, Facebook videochat	Yes	No	Student
20			Female	24					No	Yes when play video games	Student
21	Couple 11	No	Male	25	4 months	4 months	Continental Distance	Skype, FaceTime	Yes	No	Student
22			Female	24		2 Years	Victoria - Vancouver		Yes	No	Student
23	Couple 12	No	Male	30	9 Years	1 Year	Montreal - Vancouver	Skype, not that often	No	No	Student
24			Female	30					Yes	Yes	Student

4.3. Experiment Design

I 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.

Table 2. 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.

I designed an 11-item questionnaire with 7-point Likert scale. The 11-item questionnaire was derived from previous researches on social presence and body ownership. For the measurement of social presence, I used Networked Minds Measure

(Frank Biocca et al., 2001), which has been widely used in measuring social presence in mediated environments such as online community (Shen & Khalifa, 2008) and socially embodied telepresence using robot (Adalgeirsson & Breazeal, 2010; Rae, Takayama, & Mutlu, 2013). Kasahara and Rekimoto also mentioned using Networked Minds Measure in an omnidirectional video sharing system (Kasahara & Rekimoto, 2015). In my questionnaire, Question 1 to Question 7 focused on Co-Presence, Psychological Involvements and Behavioral Engagement. These three are the main components of social presence based on Networked Minds Measure. Questions 8 to 11 were about subjective measurements of body ownership. These four questions were also based on previous experiments of body ownership (Botvinick & Cohen, 1998; Ehrsson et al., 2005). I gave each question a label for describing my results; labels are shown in Table 2. 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.

I hypothesized Overlapped View would score higher than the other two views for social presence, especially for Co-presence and Behavioral Engagement because it provides an immersive experience and it has been studied that remote partners can easily synchronize movements through an overlapped view (Iizuka et al., 2011). I 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 (Petkova & Ehrsson, 2008).

Figure 4.1 Two study rooms located on different floors. Each room has a whiteboard, a heart-shape sticker, a chair, a mirror, and an iPad

4.4. Procedure

I first asked participants to fill out a survey (Appendix E) to get basic information of their age, occupation, and the relationship with the partner. The survey also included questions about their previous experience in LDRs, how frequently they used video chat, and if they had motion sickness in virtual reality before. Then I gave a short demo of MyEyes. Next, I put couples in different rooms located on two different floors of the same building. The setting inside the rooms is shown in Figure 4.1.

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

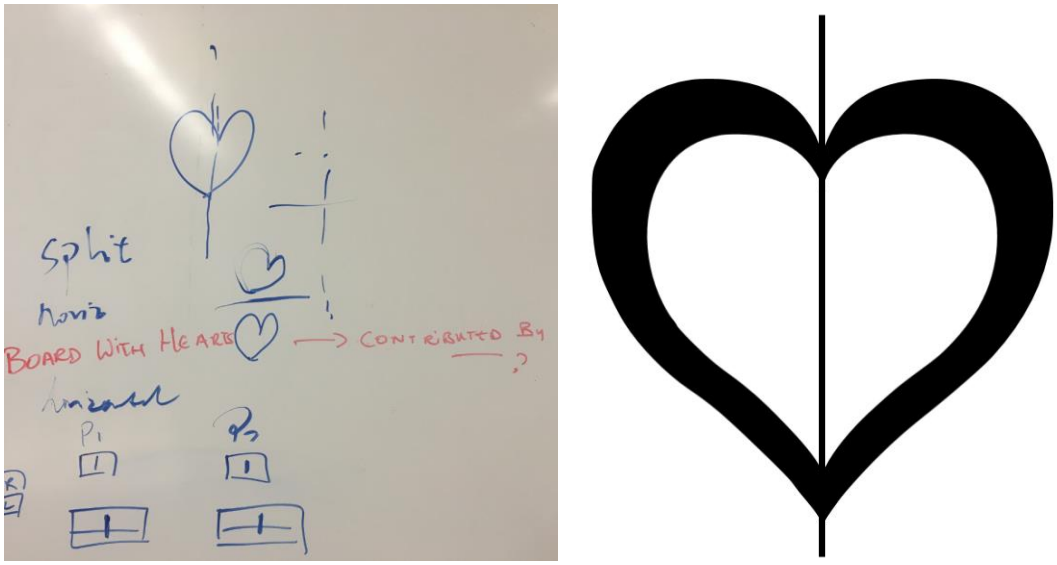

Figure 4.2 Reiteration of tasks (left) and the heart shape used for Task 1

Figure 4.3 Task 1: Aligning Shape

Figure 4.4 Task 2: Constructing Alphabet

Figure 4.5 Task 3: Arm Stroking

Task 1: Aligning Shape - Participants sat on a chair, facing the white board. I 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, I asked them to make the shapes vertically aligned instead. This task requires view synchronization for couples. I imagined the heart shape to be a metaphor for the couple's relationship. This task mapped to the everyday situations where couples need to 'look at' or 'focus on' artifacts in their view. Figure 4.2 shows the heat shape sticker used in Task 1. Figure 4.3 shows the Task 1.

Task 2: Constructing Alphabets - Participants sat on a chair facing the white board. I 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 (Massimi & Neustaedter, 2014). This task also mapped to the everyday situations where couples use hand gestures to point, indicate or draw attention on everyday objects in their view. Figure 4.4 shows the Task 2.

Task 3: Arm Stroking - I 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, I asked them to make the arms vertically aligned instead. Then I asked them to use their right hand to gently and slowly stroke the left arm of their partner synchronously. I imagined this might resemble gentle and intimate physical acts that couples are familiar with and are likely to share in everyday life. This task lasted for one minute. This task requires virtual touching, the coordination of hand movements in motion, as well as view synchronization. Figure 4.5 shows the Task 3.

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

In addition, the levels of the difficulty for the tasks increased as they went because I assumed FPVs would be relatively new for participants. Seven participants did

not have prior experience using head mounted displays or similar technologies. Hence, I setup the tasks to help them smoothly bridge into the experiment. Participants would act more naturally when they are familiar with the system. The other reason I selected these tasks is that they mapped to basic real-life actions for couples. The order of using the interfaces was counterbalanced so there were six different combinations of the interfaces. I had 12 pairs of participants so each order of using the interfaces was tested by two pairs. The three tasks for each interface lasted for ~10 minutes in total. After each round of testing (each condition), I asked the participants to fill out the questionnaire. I used a 7-point Likert scale in the questionnaire. After three rounds of testing, I 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 interfaces). Here I 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. The interview questions can be found in Appendix H.

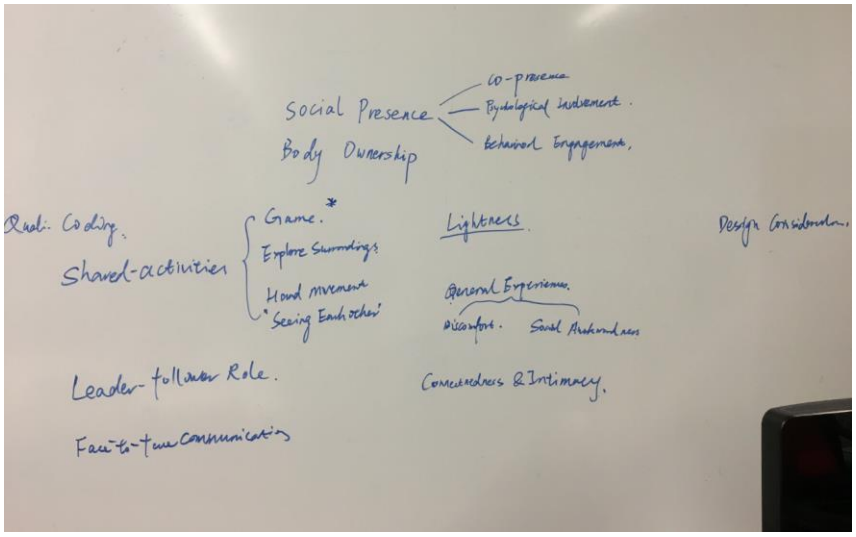

Figure 4.6 Reiteration of coding process on white board

4.5. Data Collection & Analysis

I conducted a one-way repeated measure analysis since my participants were exposed to all three conditions. I applied a Shapiro-Wilk test for testing normality of my data. The results showed that none of the responses for the 11 questions were normally distributed (ps < .0007). I 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 I applied Bonferroni Correction, resulting in a significance level at p < .017 in post-hoc tests. Statistical tests were run in SPSS. I will describe the detail about the quantitative result in next chapter.

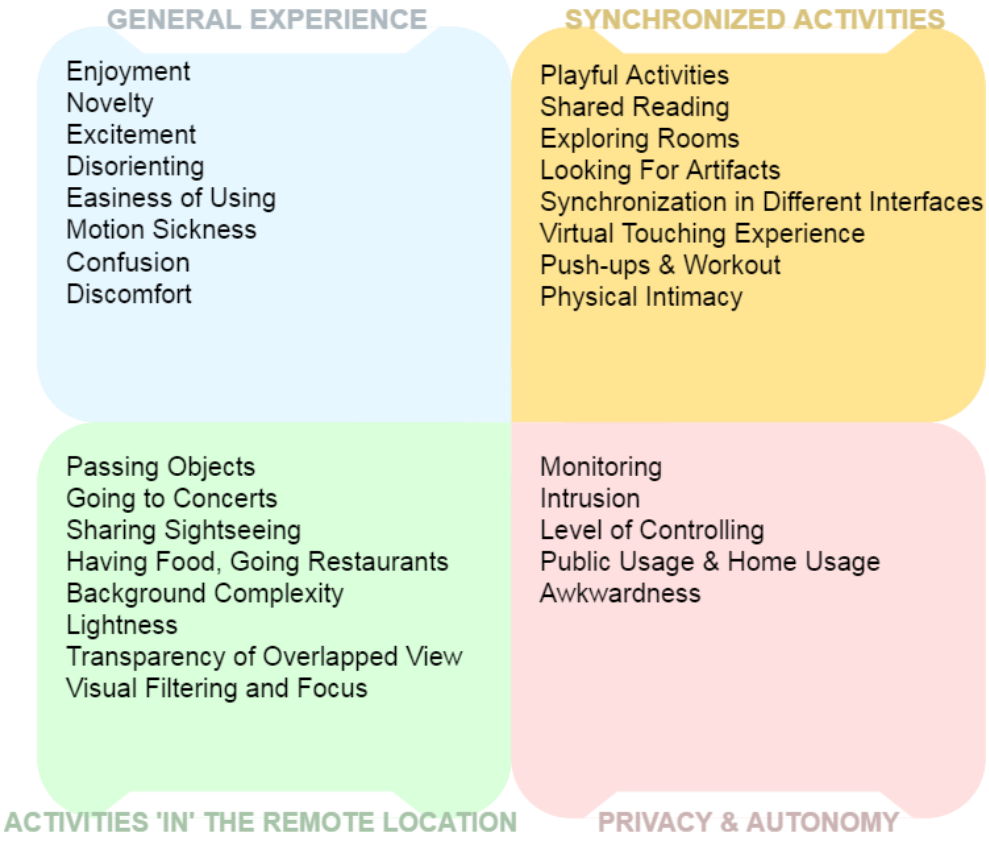

Figure 4.7 Qualitative codes and themes

I used open, axial, and selective coding to find main categories and themes in my interview transcripts. I used thematic coding on my video recordings to categorize the

activities that occurred during the exploratory sessions. I first went through the transcript of interviews and observational video records. I then found low-level findings, including experience of using MyEyes for first time, playful games, book reading, pick & hand on artefact, home/public usage, lighting, surroundings, background etc. The process of finding main themes involved the discussion and meeting with supervisor and colleagues. I eventually summarized General Experience, Synchronized Activities, Activities 'In' the Remote Location, and Privacy & Autonomy as the four main themes from qualitative data. I will describe the codes and themes in detail in next Chapter. Figure 4.7 shows the qualitative codes from the video recordings and interview transcripts.

4.6. Summary

In this chapter, I described the methods of my study for evaluating MyEyes, a FPV video streaming system for LDRs. I designed a mixed-method study including qualitative and quantitative data collection and analysis. 12 pairs of participants were recruited for the study. The experiment contains repeated measures of the three interfaces designed for MyEyes. Each pair of couples was asked to use MyEyes to complete three short tasks and an exploratory session for each interface. The quantitative data was collected through an 11-item questionnaire with questions concerning social presence and body ownership using Likert scales. I conducted one-on-one interviews with every participant and recorded them as qualitative data. Friedman tests and Wilcoxon Signed Rank tests were used to test if there was an effect of the interface type on feelings of social presence and body ownership of users. I used open, axial, and selective coding for qualitative data analysis and converged on four main themes. I describe my results from the study in the next chapter.

Chapter 5. Results

In this chapter, I describe the results of my study on evaluating a First Person View video sharing system for couples. This study addresses my three research questions: 1) We do not know how to design FPV systems for long distance couples for their daily usage; 2) We do not know whether FPV systems can help long distance couples to feel their partner's body to stay intimate; and, 3) We do not know how long distance couples would use a FPV system to communicate and share activities. The study includes both quantitative and qualitative data collection. The quantitative data is from participants' responses to the 11-item questionnaire. The qualitative results were grounded in interview transcripts and video recordings. The first section of this chapter reports on the quantitative results and the second section reports on the qualitative results.

5.1. Quantitative Results

I asked participants to fill the 11-item questionnaire individually for each interface they used. The total number of the responses from a single participant was 33 (11items × 3 interfaces). Participants gave their response on a 7-Point Likert scale to each question. I used JMP and IBM SPSS for the quantitative data analysis. I applied Freidman test as the data was not normally distributed and non-parametric. I describe the findings and hypothesis testing on social presence and body ownership in this section.

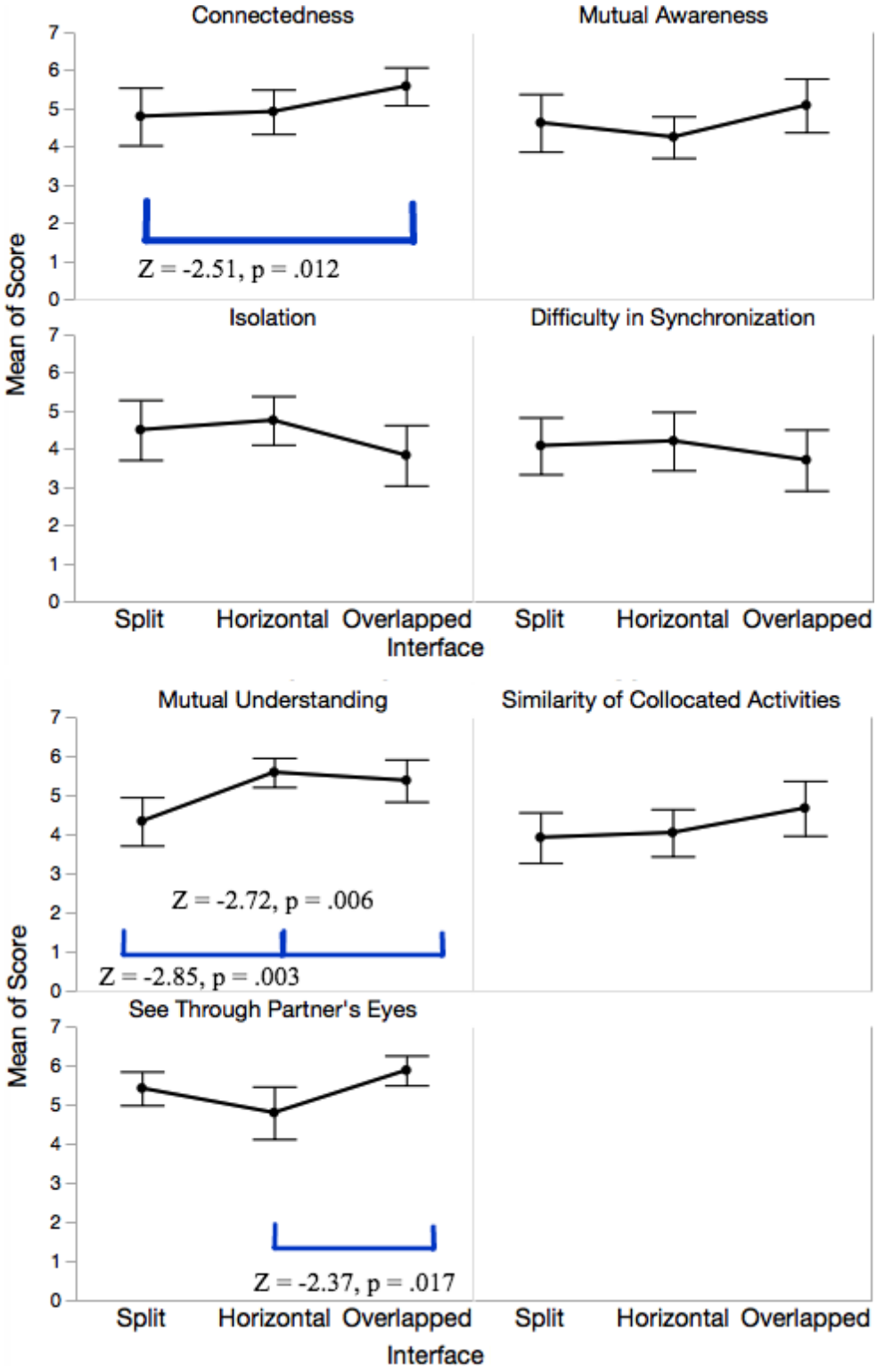

Figure 5.1 **The line chart depicts the mean and confidence interval (CI = .95) of score for questions related to social presence across three interfaces (Q1-Q7 in Table 2)**

5.1.1. Social Presence

Questions 1, 2 and 6 in my 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 5.1, I calculated the means for every combination (interface-question) 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. I 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).

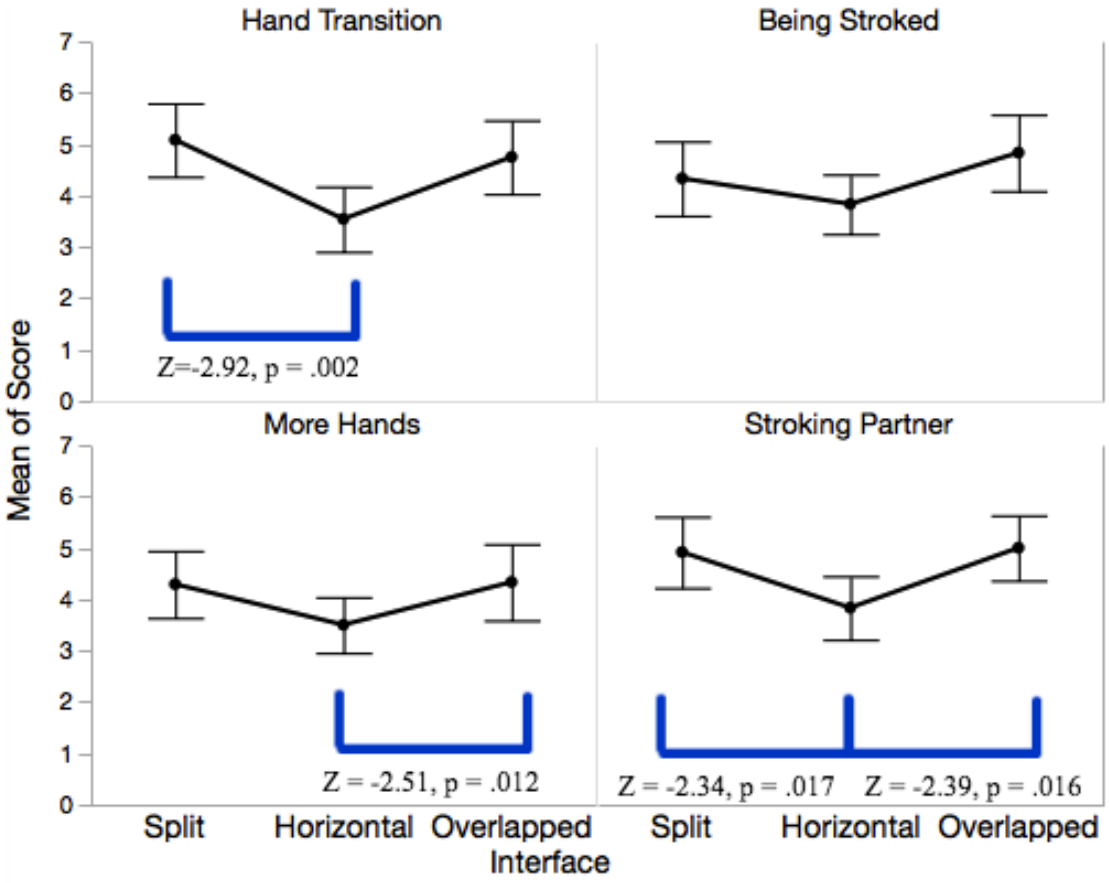

Figure 5.2 **The line chart depicts the mean and confidence interval (CI = .95) of score for questions related to body ownership across three interfaces (Q8 – Q11 in Table 2)**

5.1.2. Body Ownership

The measure of body ownership was derived from questionnaires from researchers studying rubber hand illusions (Botvinick & Cohen, 1998; Costantini & Haggard, 2007). Figure 5.2 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 ($M_{S\text{-}Q9} = 5.08$, $SD_{S\text{-}Q9} = 1.70$, $M_{H\text{-}Q9} = 3.54$, $SD_{H\text{-}Q9} = 1.50$). Overlapped View had a higher score than Horizontal View in feelings of More Hands ($M_{O\text{-}Q8} = 4.33$, $SD_{O\text{-}Q8} = 1.76$, $M_{H\text{-}Q8} = 3.50$, $SD_{H\text{-}Q8} = 1.29$). Moreover, Overlapped View and Split View both had significantly higher scores for feelings of Stroking Partner

($M_{O\text{-}Q10}$ = 5.00, $SD_{O\text{-}Q10}$ = 1.50, $M_{S\text{-}Q10}$ = 4.92, $SD_{S\text{-}Q10}$ = 1.64, $M_{H\text{-}Q10}$ = 3.83, $SD_{H\text{-}Q10}$ = 1.47). In essence, both Overlapped and Split View provided higher body ownership of participants' partner's than Horizontal View. The difference between Overlapped and Split View was not significant in the responses related to body ownership.

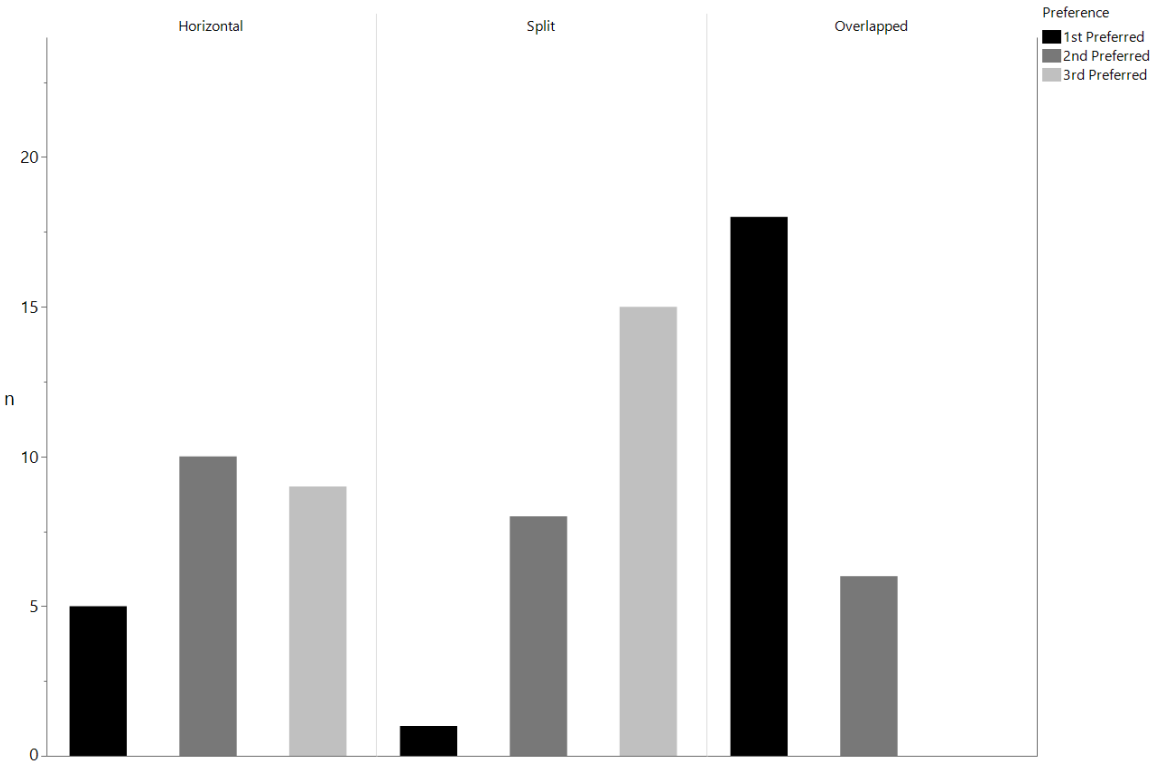

Figure 5.3 The bar chart showing participants' ranks of preference over three interfaces. ("1st Preferred" means "Favorite"). Overlapped View has zero "3rd Preferred"

5.1.3. Preference

I 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 5.3 shows the distribution of participants' preference.

5.2. Qualitative Results

The qualitative results were based on the analysis of individual interviews with couples and video recordings of the experiment process. This included the three tasks and the exploratory session for each interface. In this section, I described the main qualitative themes that I found.

5.2.1. 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 provided 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

“It was cool. I have never had anything like that before.” - P4, Female

Figure 5.4 Participants laughing when using MyEyes with the partner

From the video recording, participants expressed positive attitudes and joyous movements such as laughing, dancing and talking with their partner with an energetic tone (Figure 5.4). P23 and P24 could not help themselves from laughing when they were doing activities together.

Some participants pointed out that they would focus more on the audio channel when using Skype while they said that they focused more on the video feed when using MyEyes:

> *"Umm, It was very different (compared to Skype). I mean cuz it was visual mostly. And Skype is, I could really only pay attention like to the sound."* – P4, Female

The design was not without 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 the 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.

5.2.2. Synchronized Activities

In the post-experiment interviews, participants told me 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 me that synchronization became especially salient in Overlapped View and Split View. The rationale of designing Overlapped View and Split View is that both could support movement synchronization in a distributed setting. This result echoed my 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

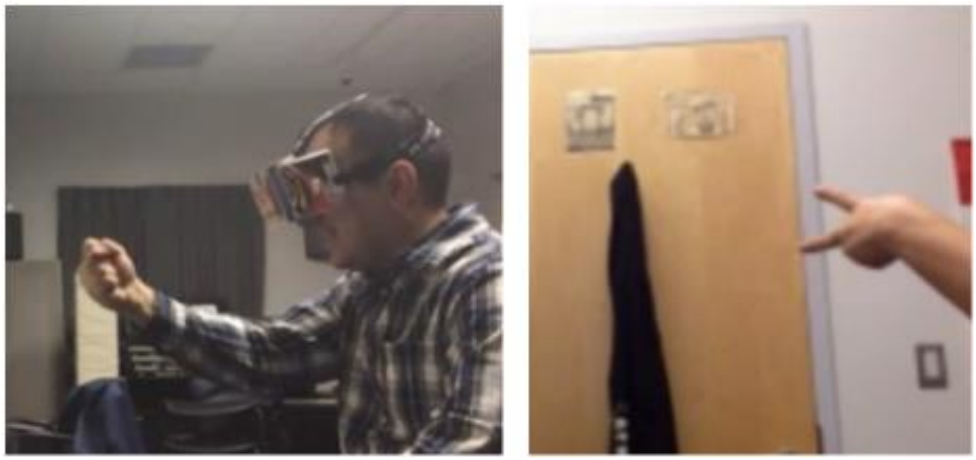

Figure 5.5 Participants playing Rock Paper, Scissors using MyEyes in exploratory sessions

The benefits of synchronization were further elucidated during the exploratory sessions. More than half of my 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 5.5) 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

Figure 5.6 A participant tried to 'share' a view of his feet to the partner

Some participants tried to overlap their shoes or feet (Figure 5.6). This revealed that although hand movements dominated the exploratory sessions, participants were also curious about the ownership of other parts of their body.

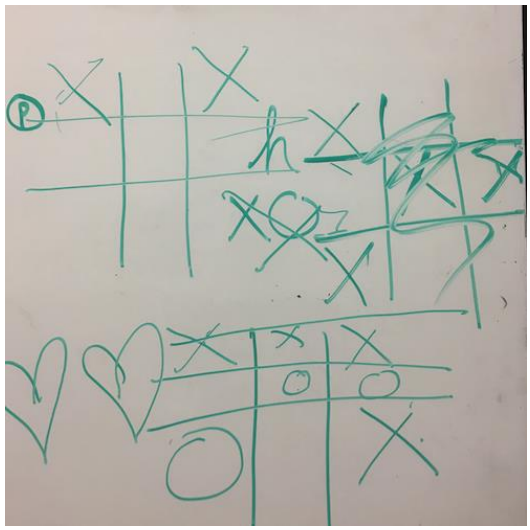

Figure 5.7 P21 and P22 played tic-tac-toe using MyEyes. They drew their moves on the white board so they could see the partner's moves on the screen by using Split View

P21 and P22 played tic-tac-toe in both Split View and Overlapped View on the white board (Figure 5.7). 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.

Interestingly, P1 and P2 even played piano 'together.' P1 described the experience as follows:

> *"We tried the piano in the room. When I saw there were three hands on the keys, that was quite interesting… If she can also make some sounds from a piano, that would be really good*." - P1, Male

The mentioned activities benefitted from the characteristics of FPVs, which include being able to see through a partner's eyes and augment part of the body in a remote view. The quote also revealed that the lack of piano's sound impacted their experience. P2 also gave her comments on the experience of playing piano with her partner and compared it with the usage of existing video chatting tools:

> *"I think for some activities, this (FPV video chat) could be better (than traditional video chat), like when we played the piano together. He was facing a piano and I was facing a white desk. But for some activities that I can imagine, like going out for dinner, our backgrounds will be too complicated and the things overlapped will be too many, then it's gonna be meaningless. So I think maybe one side complicated and one side simple is better."* - P2 Female

P2 gave positive comments about using MyEyes to virtually play piano with her partner. She also mentioned that the complexity of the video background might have an effect on understanding the partner's streaming situation.

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

5.2.3. 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. This reflects an 'asymmetric' activity sharing type in FPV video sharing.

"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

Figure 5.8 The male participant tried to 'virtually' catch a chair in his partner's room

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'. I 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 5.8).

The environment sometimes made it difficult to perform the aforementioned activities. This involved challenge 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 because users had to see both local and remote images merged in the same video frame at the same time. 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 workarounds for overcoming environmental problems. Here they utilized lighting and different background colors to 'switch' between seeing the local view and the remote view. For example, in Overlapped View, if one looked at a dark area in their room, it was easier for them to focus on the remote partner's streaming because their own view was somewhat 'filtered out' due to the darkness.

> *"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.

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

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.

5.2.4. 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., intimate 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

I had posited that having a sense of body ownership over one's remote partner may cause an intrusive feeling because 'owning' another person's body is often considered a private and intimate act. However, none of my participants brought up the concern that giving up one's body ownership could lead to intrusive feelings.

5.3. Summary

This chapter addressed three research questions: 1) We do not know whether FPV systems can help long distance couples to feel social presence; 2) We do not know whether FPV systems can help long distance couples to gain body ownership remotely; and, 3) We do not know how long distance couples would use a FPV system to communicate and share activities. In this chapter, firstly, I summarized the quantitative results based on my 11-item questionnaire (Table 2) regarding social presence and body ownership. I also included a section for describing participants' preference of the three interfaces. Generally speaking, Overlapped View and Split View provided a relatively stronger body ownership of their partner compared to Horizontal View. In a question related to Mutual Understanding of social presence, Horizontal View scored higher than the other two. More participants picked Overlapped View as their favorite among the

three. More than half of my participants ranked Split View as third preferred (like the least). Secondly, I described the findings in the main themes grounded in my interview transcripts and video recordings. The themes are 1) Synchronized Activities; 2) Activities ‘in Remote Location; and, 3) Privacy and Autonomy. My qualitative results show that couples found MyEyes to be a novel and fun system for sharing first person perspectives in video chatting and they would want to use the system for future activity sharing. Two types of activities—synchronized activities and asymmetric activity sharing—are described in the qualitative findings. I also described privacy and autonomy concerns raised by participants. In the next chapter, I use the findings of this chapter as a basis for discussing the design implications for future FPV systems.

Chapter 6. Discussions and Design Implications

In this chapter, I summarize the main findings from my quantitative and qualitative results and discuss: (1) how could a FPV system like MyEyes help couples stay intimate and connected when they are geographically separated; (2) what kind of shared activities can benefit from a FPV system like MyEyes and how could we better design FPV systems for these activities; (3) design implications to address privacy concerns in future FPV systems; and (4) the comparison between MyEyes and existing video chat systems. This chapter addresses the research questions and research goals presented in Chapter 1 about how to design a FPV video chatting experience for long distance couples.

6.1. First Person Views and Intimacy

One of my Research Problems is "We do not know whether FPV systems can help long distance couples to feel social presence." Solving this problem can help me understand new approaches to let long distance couples stay connected. I 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 participants and it provided the strongest feeling of Co-Presence. However, contrary to my 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 my study goals was to explore whether researchers could use a rubber hand illusion to create a sense of virtual touching between partners. My 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 (Ehrsson et al., 2005; Maister et al., 2015; Petkova & Ehrsson, 2008). 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 (Kasahara et al., 2016). I extended these results to show that a similar feeling occurs when distance-separated couples are connected in FPVs. Moreover, given that couples in my study liked exploring a variety of different activities with FPVs, my 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. My research suggests promise for such explorations. These ideas are also suggested by previous researchers when it comes to designing video communication systems for couples (Neustaedter & Greenberg, 2012).

6.2. Shared Activities over Distance

My qualitative results showed that participants liked to do a range of *synchronized activities* together over distance, such as synchronized playful activities. 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 with 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, especially for Overlapped View because it had a lower Mutual Understanding score than Horizontal View in the quantitative results. That indicates that adding a clear indication of remote and local image in an Overlapped View is likely necessary.

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 of the movement between partners in terms of what they were doing, though one partner would have to maintain a relatively fixed view during interaction. Examples are virtual touring, remotely attending concerts or virtually shopping together. In these scenarios, one user could act as a 'streamer' and the other could act as a 'viewer'. 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. Although this asymmetric 'streamer-viewer' streaming paradigm has been studied heavily in video chatting systems (Baishya & Neustaedter, 2017; Kasahara et al., 2016; Kasahara & Rekimoto, 2015), few researchers have studied the effect of different interfaces (or how to visually present the video feed) on users' experiences in a FPV video chatting. I comparatively studied three interfaces: Split View, Horizontal View and Overlapped View. Based on the results of my study on MyEyes, 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 (Neustaedter & Greenberg, 2012). 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 found in my study but could work well for activities focused on being 'in' the remote space and creating a stronger sense of mutual understanding and empathy.

6.3. 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 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 could 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. Some expressed concerns when using MyEyes in public spaces because they preferred to use it at home or private rooms. 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. Further studies could also investigate and compare the behaviors of users when they use FPV systems in public and private spaces.

6.4. Comparison to Existing Video Systems

Although existing video chat systems (i.e. Skype, FaceTime and Google Hangouts) help long distance couples keep regular communication through face-to-face chatting styles, they are limited in supporting new perspectives for shared activities and providing a sense of embodied intimacy. The related work of my thesis revealed that users now expect the support for new usage scenarios in video chatting such as outdoor activities, city exploring and the attendance at major life events (Baishya & Neustaedter, 2017; Neustaedter & Greenberg, 2012; Neustaedter, Venolia, Procyk, & Hawkins, 2016; Procyk et al., 2014). In the study of MyEyes, many participants stated that 'seeing through' partner's eyes was a novel and cool experience for them. Although I did not conduct studies on how couples could video chat with MyEyes in an outdoor setting, some participants compared MyEyes with Skype, which they used before in a long distance relationship, and felt that MyEyes gave them new perspectives for sharing activities such as workouts and outdoor activities. Also, both quantitative and qualitative results showed that Overlapped View and Split View could provide a sense of real touching, which adds a novel dimension in video chatting that supports embodied intimacy. While beneficial, a few participants still valued more traditional face-to-face video communication and expressed their preference for seeing their partner's face when video chatting. MyEyes is limited in providing such an experience. Other participants mentioned that the equipment (cardboard goggles and smartphone) was somewhat heavy and uncomfortable to wear for a long period of time. This indicates that the future design of FPV systems for long distance couples should consider the benefits received from systems like MyEyes, while balancing some people's desires to still have access to a face-to-face video style (e.g., Skype-style) and designs aimed at lightweight and long-term usage.

Participants praised the simple and economic hardware design of MyEyes and thought it was more practical to use than pricy Virtual Reality headsets such as HTC Vive and Oculus Rift, although one participant thought the performance was below expectation if compared to those sophisticated headsets. On the other hand, almost all participants expressed their desire to use FPV system like MyEyes in the future with their partner. This suggests a large potential for future FPV systems.

Neustaedter and Greenberg's study on intimacy of couples in video chatting suggested design for mobility and shared activities (Neustaedter & Greenberg, 2012) . I proposed a new design of video communication tool with affordable hardware components and an easy-to-use online web app with multiple interfaces to help long distance couples share first person views. My study results showed that two types of shared activities would be popular with FPV systems: Synchronized Activities and Activities 'in' the Room. These two represent symmetric and asymmetric video sharing in First Person View video systems discussed in Kasahara et al's study (Kasahara et al., 2016). While their findings of symmetric and asymmetric video sharing are novel, my study focused on how to utilize the features for long distance couples to support their every day activities sharing, rather than focus on professional training and skill transitions. Compared to the study of In Your Eyes (Baishya & Neustaedter, 2017), while similar, I proposed a new system design and conducted a study with a larger population. The study of In Your Eyes (an 'anywhere and anytime' technology probe) found the technology probe could give rise to intrusive feelings. However, none of my participants reported feelings of intrusiveness when their partner 'owned' their body through MyEyes. However, it might be interesting to investigate if it will be intrusive to use similar systems for other family members, friends or even strangers.

6.5. Summary

This chapter describes the discussion based on my study results, including social presence and intimacy provided in MyEyes, shared activities benefited from FPV systems, privacy and autonomy concerns, and the comparison between MyEyes and existing video systems. In this chapter, I first discussed how MyEyes could help couples feel intimate and provide a virtual touching experience based on the theory of social presence and body ownership. Overlapped View and Split View helped couples 'feel' the hand of their partner during the study. However, Horizontal View could lead to higher mutual understanding to help couples understand local and remote ongoings more clearly. This indicates that using a FPV system to provide a virtual touching/stroking experience could be possible. A recurring theme in my exploratory sessions was sharing activities through MyEyes. The third section of the chapter discussed the shared

activities and how to better design FPV systems to support these in the future. Design implications include designing for augmented interfaces (e.g., showing only the partner's hand in local view), asynchronous video sharing (e.g., first person view video recording and sharing), and enhancements to each interface proposed for MyEyes.

Of course, new privacy concerns would arise when using FPV systems like MyEyes. I summarized the design implications to help couples mitigate privacy concerns. This included the possibility of new blurring mechanisms for portions of video feeds.

In the end, I described the novelty of MyEyes based on what my participants stated. Couples found it to be a novel and cool way to connect their partner when in LDR. Affordable designs and the ability to see through one's partner's eyes were appreciated. A shortcoming was being unable to provide face-to-face communication some of the time as couples would also like to see the face of their loved one, at least periodically.

Chapter 7. Conclusion

This chapter concludes my thesis where I describe how I addressed the research problems described in Chapter 1. I also present the limitations of the study and areas for future work.

7.1. Thesis Problems

The overarching research problem in the thesis is: *we do not know how to design first person view video systems to help long-distance couples maintain their relationship and how they will use them*. In Chapter 1, I described the following four specific research problems:

1. **We do not know how to design FPV systems for long distance couples.** Existing video chatting systems are limited in providing flexibility and new perspectives for couples to see each other and share activities. First Person View video systems are a new type of video communication that can help synchronize movements of local and remote users easily (Iizuka et al., 2011). However, how to design FPV systems for long distance couples to provide a richer communication medium is unknown.

2. **We do not know whether FPV systems can help long distance couples feel social presence.** Social presence is defined as "the feeling of being together at the same place" in the thesis (Frank Biocca et al., 2003). It is important in relationship maintenance for couples (Canary & Stafford, 1994). Whether FPV systems could help long distance couples feel social presence in video chatting to maintain a strong relationship still remains unknown.

3. **We do not know whether FPV systems can help long distance couples gain feelings of body ownership remotely.** Touching experience and

embodiment in intimacy are important in relationship maintenance but difficult to realize in a traditional video chatting (Neustaedter & Greenberg, 2012). Researchers have found FPV systems can trigger body restoring/swapping experience to provide feeling of body ownership of others (Kasahara et al., 2016). However, whether we could utilize the feeling of body ownership in FPV video chatting to help long distance couples feel touching experience is unknown.

4. **We do not know how long distance couples would use a FPV system to communicate and share activities.** Video communication is now extended to allow users to share every day activities. Yet we still know little about how FPV systems could help long distance couples share activities. Answering this question can help design FPV systems better to share activities.

7.2. Contributions

To address the research problems, my goal was to design and evaluate a FPV system for couples to maintain relationship over distance. To achieve the goal, I first designed a FPV system called MyEyes. I then conducted a study with 12 pairs of couples using both qualitative and quantitative research methods. This research generated the following contributions:

1. **A FPV video chat system called MyEyes with three visual representations of video feed.** Chapter 3 described the hardware and software designs of MyEyes, a first person view video chat systems for long distance couples. I also introduced the design process including initial design, pilot study, lessons learnt and the final design of MyEyes. The design requires affordable cardboard goggles and smartphones. The web-based video chat app uses modern web technologies including HTML5, JavaScript and WebRTC. An online switch is designed for toggling interfaces remotely. Users could use MyEyes to video chat with their partner in first person perspective without sophisticated hardware requirement or scripted testing environments. Also, I designed three interfaces of MyEyes and gave design implications for future FPV systems by running a comparative study.

2. **A comparison of three visual representations in MyEyes in terms of the feeling of social presence.** In Chapter 4, I designed a within-group study using qualitative and quantitative research methods to evaluate MyEyes with 12 pairs of participants. The measurement of social presence was the Networked Minds Measure which breaks down social presence to three main components including Co-Presence, Psychological Involvement and Behavioral Engagement. The results showed that while most of my participants acknowledged MyEyes as a novel and fun way to connect with their partners, Overlapped View provided the highest score in Co-Presence yet Horizontal View provided the highest score in Psychological Involvement. This indicated that FPV systems could provide strong social presence but future designers should carefully balance the three components of social presence.

3. **A comparison of three visual representations in MyEyes in terms of the feeling of body ownership.** The other aim of the within-group study was to investigate which interface could provide stronger feeling of body ownership to help couples share a touching experience, which was missing in existing face-to-face video chatting. Results showed that Overlapped View and Split View could help create a feeling of owning a remote partner's body and share a sense of arm stroking. I extended the findings in previous experiments of the Rubber Hand Illusion and found that FPV systems could be a possible solution for offering a sense of touching between partners by simulating embodiment within a partner's body. While beneficial, new privacy and autonomy concerns also arose.

4. **An understanding of how couples could use MyEyes to communicate and share activities through exploratory sessions and interviews.** I extracted the usage patterns from my video records and interview transcripts concerning how they used MyEyes to share activities and how they would like to use FPV systems in the future. I found there were two types of activities that couples liked to share during the study: Synchronized Activities and activities 'on behalf of' the other. My Chapter 6 also addressed the privacy concerns of couples when using MyEyes. These results pointed to design

implications to help researchers and designers better design FPV systems for long distance couples.

7.3. Limitations

My 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), I had to conduct the study with couples who were not currently in a LDR. I tried to mitigate the effects of this difference by having eight pairs of participants who had previously been in a LDR. 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. I 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 I received from participants did not reveal any obvious differences. Nonetheless, my research is limited by my participant sample. Although I counterbalanced the order of using interface for different couples, order effect might be neglected because of the small sample size. People presently in a LDR would likely not be able to see each other or have any physical interactions in person as compared to collocated couples, which could cause different results to appear in a study like mine where they may have additional longing to be together. Another limitation in my study is that the age range of my participants fell within a young age group (21-31 years old). Users in different age groups may have different capabilities when it comes to adopting new technologies. Understanding the usage behaviors of youth, elders, and even children more generally (not as a part of long distance relationships), can help us understand how to design more universal and adoptable first person view video chatting experiences. Overall, future research should explore participants within real LDRs and have diversity in different age groups.

7.4. Future Work

The system design and evaluation of MyEyes is a preliminary attempt to investigate the potential of using FPV systems for long distance couples to help maintain

their relationship. Future work could focus on other groups of users such as friends or even strangers to investigate social norms and privacy concerns. I focused on long distance couples in my thesis as I wanted to increase intimacy and maintain connectedness during video chatting for them. But how could we utilize first person view video sharing for other purposes? For example, one could explore how two strangers could know each other by 'seeing through' the other person's eyes. Other researchers could investigate how FPV systems could help medical support groups use FPV systems to virtually comfort each other remotely and build a more connected community. For game designers, they might find FPV systems useful when designing games that required high immediacy in synchronization between players. I believe FPV systems offer potential for LDRs such as providing a flexible and broader perspective of exchanging video while video chatting and sharing a sense of touch to help maintain relationships.

For sharing activities via FPV systems, I summarized two main types of activities that couples would like to share. However, some of the activities (e.g., workout together, dinner sharing) were based on participants' verbal descriptions of their imagination instead of conducting empirical study on these activities. Future work could ask participants to really 'do' specific activities to more deeply explore the usage patterns for FPV systems in particular contexts. For example, one could run a study on the outdoor usage of FPV systems by asking participants to run/walk together using MyEyes.

I compared three different visual representations of video feeds in MyEyes—Split View, Overlapped View and Horizontal View—in terms of social presence and body ownership. Further studies could investigate other aspects such as usability, efficiency of communication and new interface designs. As participants stated that they wanted to have control of what they see in different views, it would be interesting to study how users could control the transparency of local/remote views based on contextual information (e.g., location, walking speed, surrounding environments). This can help researchers design futuristic video chatting experience and enable contextual awareness in video chatting. For example, transparency could allow users to see the remote location at varying degrees so they might be able to switch between seeing only their own location or the remote location. Contextual information such as walking speed

and location could provide new control mechanism of how video should be displayed (e.g. video paused when walking too fast).

In terms of the hardware design, MyEyes used a simple solution of using cardboard goggles and a smartphone. As participants said it was a bit large and tiring to wear it, researchers and designers could come up with new designs of hardware for a more comfortable and convenient chatting experience. On the other hand, for the software and connectivity of video chat applications, ensuring high stability in connection and video stabilization is important for users. Future studies should think about how to make sure that users have a decent video chatting experience in conditions of varying connectivity. Reducing motion sickness and helping users navigate while moving around are also important topics in FPV system designs.

7.5. Final Words

Long distance couples often face difficulties in maintaining their relationship and staying connected (Stafford, 2004). Although existing video systems can provide face-to-face chatting experiences, couples often still have a difficult time feeling like they are 'with' their partner and sharing physical intimacy (Neustaedter & Greenberg, 2012). In this thesis, I designed a first-person view video chatting system for long distance couples called MyEyes. Based on the results of my mixed-method study with 24 participants, MyEyes could provide a sense of feeling partner's body and strong social presence. Participants also found MyEyes valuable in sharing activities. This thesis illustrated new design spaces on how to utilize first person views in video chatting to help people feel presence and gain embodiment. As the trend in video technology is moving beyond 'talking heads' (which is typical with systems like Skype or FaceTime), I believe my work has a large potential for helping reshape future designs of video chatting experiences.

In closing, the effort of bringing people together, no matter physically or virtually, continues to be important. I have used my thesis to design and evaluate a futuristic video chatting experience. Hopefully, my efforts can inspire others to build richness, affection and closeness in people's communication.

References

Adalgeirsson, S. O., & Breazeal, C. (2010). MeBot: A Robotic Platform for Socially Embodied Presence. In *Proceedings of the 5th ACM/IEEE International Conference on Human-robot Interaction* (pp. 15–22). Piscataway, NJ, USA: IEEE Press. Retrieved from http://dl.acm.org/citation.cfm?id=1734454.1734467

Baishya, U., & Neustaedter, C. (2017). In Your Eyes: Anytime, Anywhere Video and Audio Streaming for Couples. In *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing* (pp. 84–97). New York, NY, USA: ACM. https://doi.org/10.1145/2998181.2998200

Biocca, F., Harms, C., & Gregg, J. (2001). The Networked Minds Measure of Social Presence: Pilot Test of the Factor Structure and Concurrent Validity. *ResearchGate*. Retrieved from https://www.researchgate.net/publication/200772411_The_Networked_Minds_Measure_of_Social_Presence_Pilot_Test_of_the_Factor_Structure_and_Concurrent_Validity

Biocca, Frank, Harms, C., & Burgoon, J. K. (2003). Toward a more robust theory and measure of social presence: Review and suggested criteria. *Presence*, *12*(5), 456–480.

Biocca, Frank, Harms, C., & Gregg, J. (2001). The networked minds measure of social presence: Pilot test of the factor structure and concurrent validity. In *4th annual international workshop on presence, Philadelphia, PA* (pp. 1–9).

Botvinick, M., & Cohen, J. (1998). Rubber hands “feel” touch that eyes see. *Nature*, *391*(6669), 756–756. https://doi.org/10.1038/35784

Canary, D. J., & Stafford, L. (1994). Maintaining relationships through strategic and routine interaction. In D. J. Canary & L. Stafford (Eds.), *Communication and relational maintenance* (pp. 3–22). San Diego, CA, US: Academic Press.

Chang, A., Resner, B., Koerner, B., Wang, X., & Ishii, H. (2001). LumiTouch: An Emotional Communication Device. In *CHI ’01 Extended Abstracts on Human Factors in Computing Systems* (pp. 313–314). New York, NY, USA: ACM. https://doi.org/10.1145/634067.634252

Chua, P. T., Crivella, R., Daly, B., Hu, N., Schaaf, R., Ventura, D., … Pausch, R. (2003). Training for physical tasks in virtual environments: Tai Chi. In *IEEE Virtual Reality, 2003. Proceedings.* (pp. 87–94). https://doi.org/10.1109/VR.2003.1191125

Chung, H., Lee, C.-H. J., & Selker, T. (2006). Lover’s Cups: Drinking Interfaces As New Communication Channels. In *CHI ’06 Extended Abstracts on Human Factors in Computing Systems* (pp. 375–380). New York, NY, USA: ACM. https://doi.org/10.1145/1125451.1125532

Corballis, M. C. (1995). Visual integration in the split brain. *Neuropsychologia*, *33*(8), 937–959. https://doi.org/10.1016/0028-3932(95)00032-X

Costantini, M., & Haggard, P. (2007). The rubber hand illusion: Sensitivity and reference frame for body ownership. *Consciousness and Cognition*, *16*(2), 229–240. https://doi.org/10.1016/j.concog.2007.01.001

Dainton, M., & Aylor, B. (2002). Patterns of communication channel use in the maintenance of long-distance relationships. *Communication Research Reports*, *19*(2), 118–129. https://doi.org/10.1080/08824090209384839

Ehrsson, H. H., Holmes, N. P., & Passingham, R. E. (2005). Touching a Rubber Hand: Feeling of Body Ownership Is Associated with Activity in Multisensory Brain Areas. *Journal of Neuroscience*, *25*(45), 10564–10573. https://doi.org/10.1523/JNEUROSCI.0800-05.2005

Field, A., & Hole, G. (2002). *How to Design and Report Experiments*. SAGE.

Field, T. (2003). *Touch*. MIT Press.

Gooch, D., & Watts, L. (2011). A Design Framework for Mediated Personal Relationship Devices. In *Proceedings of the 25th BCS Conference on Human-Computer Interaction* (pp. 237–242). Swinton, UK, UK: British Computer Society. Retrieved from http://dl.acm.org/citation.cfm?id=2305316.2305360

Gooch, D., & Watts, L. (2012). YourGloves, Hothands and Hotmits: Devices to Hold Hands at a Distance. In *Proceedings of the 25th Annual ACM Symposium on User Interface Software and Technology* (pp. 157–166). New York, NY, USA: ACM. https://doi.org/10.1145/2380116.2380138

Harms, P. C., & Biocca, P. F. (2004). Internal Consistency and Reliability of the Networked Minds Measure of Social Presence. In M. Alcaniz & B. Rey (Eds.). Retrieved from http://cogprints.org/7026/

Iizuka, H., Kondo, D., Kawasaki, H., Ando, H., & Maeda, T. (2011). Coordinated Behavior Between Visually Coupled Dyads. In *Proceedings of the 2Nd Augmented Human International Conference* (p. 23:1–23:4). New York, NY, USA: ACM. https://doi.org/10.1145/1959826.1959849

IJsselsteijn, W. A., Kort, Y. A. W. de, & Haans, A. (2006). Is This My Hand I See Before Me? The Rubber Hand Illusion in Reality, Virtual Reality, and Mixed Reality. *Presence*, *15*(4), 455–464. https://doi.org/10.1162/pres.15.4.455

Inkpen, K., Taylor, B., Junuzovic, S., Tang, J., & Venolia, G. (2013). Experiences2Go: Sharing Kids' Activities Outside the Home with Remote Family Members. In *Proceedings of the 2013 Conference on Computer Supported Cooperative Work* (pp. 1329–1340). New York, NY, USA: ACM. https://doi.org/10.1145/2441776.2441926

Joi, Y. R., Jeong, B. T., Kim, J. H., Park, K. H., Lee, T., & Cho, J. D. (2015). WearLove: Affective Communication via Wearable Device with Gamification. In *Proceedings of the 2015 Annual Symposium on Computer-Human Interaction in Play* (pp. 559–564). New York, NY, USA: ACM. https://doi.org/10.1145/2793107.2810337

Karney, B. R., & Bradbury, T. N. (1995). The longitudinal course of marital quality and stability: A review of theory, methods, and research. *Psychological Bulletin*, *118*(1), 3–34. https://doi.org/10.1037/0033-2909.118.1.3

Kasahara, S., Ando, M., Suganuma, K., & Rekimoto, J. (2016). Parallel Eyes: Exploring Human Capability and Behaviors with Paralleled First Person View Sharing. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (pp. 1561–1572). New York, NY, USA: ACM. https://doi.org/10.1145/2858036.2858495

Kasahara, S., & Rekimoto, J. (2015). JackIn Head: Immersive Visual Telepresence System with Omnidirectional Wearable Camera for Remote Collaboration. In *Proceedings of the 21st ACM Symposium on Virtual Reality Software and Technology* (pp. 217–225). New York, NY, USA: ACM. https://doi.org/10.1145/2821592.2821608

Kawasaki, H., Iizuka, H., Okamoto, S., Ando, H., & Maeda, T. (2010). Collaboration and skill transmission by first-person perspective view sharing system. In *19th International Symposium in Robot and Human Interactive Communication* (pp. 125–131). https://doi.org/10.1109/ROMAN.2010.5598668

Kim, J., Park, Y.-W., & Nam, T.-J. (2015). BreathingFrame: An Inflatable Frame for Remote Breath Signal Sharing. In *Proceedings of the Ninth International Conference on Tangible, Embedded, and Embodied Interaction* (pp. 109–112). New York, NY, USA: ACM. https://doi.org/10.1145/2677199.2680606

Kuzuoka, H. (1992). Spatial Workspace Collaboration: A SharedView Video Support System for Remote Collaboration Capability. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 533–540). New York, NY, USA: ACM. https://doi.org/10.1145/142750.142980

Kuzuoka, H., Kosuge, T., & Tanaka, M. (1994). GestureCam: A Video Communication System for Sympathetic Remote Collaboration. In *Proceedings of the 1994 ACM Conference on Computer Supported Cooperative Work* (pp. 35–43). New York, NY, USA: ACM. https://doi.org/10.1145/192844.192866

Maister, L., Sebanz, N., Knoblich, G., & Tsakiris, M. (2013). Experiencing ownership over a dark-skinned body reduces implicit racial bias. *Cognition*, *128*(2), 170–178. https://doi.org/10.1016/j.cognition.2013.04.002

Maister, L., Slater, M., Sanchez-Vives, M. V., & Tsakiris, M. (2015). Changing bodies changes minds: owning another body affects social cognition. *Trends in Cognitive Sciences*, *19*(1), 6–12. https://doi.org/10.1016/j.tics.2014.11.001

Manusov, V. (2006). Maintaining long-distance and cross-residential relationships - by Laura Stafford. *Journal of Communication*, *56*(3), 630–631. https://doi.org/10.1111/j.1460-2466.2006.00307.x

Maselli, A., & Slater, M. (2013). The building blocks of the full body ownership illusion. *Frontiers in Human Neuroscience*, *7*, 83. https://doi.org/10.3389/fnhum.2013.00083

Massimi, M., & Neustaedter, C. (2014). Moving from Talking Heads to Newlyweds: Exploring Video Chat Use During Major Life Events. In *Proceedings of the 2014 Conference on Designing Interactive Systems* (pp. 43–52). New York, NY, USA: ACM. https://doi.org/10.1145/2598510.2598570

Montagu, A. (1971). *Touching: the Human Significance of the Skin*. Columbia University Press.

Neustaedter, C., & Greenberg, S. (2012). Intimacy in Long-distance Relationships over Video Chat. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 753–762). New York, NY, USA: ACM. https://doi.org/10.1145/2207676.2207785

Neustaedter, C., Venolia, G., Procyk, J., & Hawkins, D. (2016). To Beam or Not to Beam: A Study of Remote Telepresence Attendance at an Academic Conference. In *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing* (pp. 418–431). New York, NY, USA: ACM. https://doi.org/10.1145/2818048.2819922

Nowak, K. L., & Biocca, F. (2003). The Effect of the Agency and Anthropomorphism on Users' Sense of Telepresence, Copresence, and Social Presence in Virtual Environments. *Presence: Teleoperators and Virtual Environments*, *12*(5), 481–494. https://doi.org/10.1162/105474603322761289

Pan, R., & Neustaedter, C. (2017). Streamer.Space: A Toolkit for Prototyping Context-Aware Mobile Video Streaming Apps. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems* (pp. 1947–1954). New York, NY, USA: ACM. https://doi.org/10.1145/3027063.3053083

Pan, R., Neustaedter, C., Antle, A. N., & Matkin, B. (2017). Puzzle Space: A Distributed Tangible Puzzle for Long Distance Couples. In *Companion of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing* (pp. 271–274). New York, NY, USA: ACM. https://doi.org/10.1145/3022198.3026320

Patton, M. Q. (1990). *Qualitative evaluation and research methods, 2nd ed*. Thousand Oaks, CA, US: Sage Publications, Inc.

Petkova, V. I., & Ehrsson, H. H. (2008). If I Were You: Perceptual Illusion of Body Swapping. *PLoS ONE*, *3*(12), e3832. https://doi.org/10.1371/journal.pone.0003832

Procyk, J., Neustaedter, C., Pang, C., Tang, A., & Judge, T. K. (2014). Exploring video streaming in public settings: shared geocaching over distance using mobile video chat (pp. 2163–2172). ACM Press. https://doi.org/10.1145/2556288.2557198

Rae, I., Takayama, L., & Mutlu, B. (2013). In-body Experiences: Embodiment, Control, and Trust in Robot-mediated Communication. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 1921–1930). New York, NY, USA: ACM. https://doi.org/10.1145/2470654.2466253

Shen, K. N., & Khalifa, M. (2008). Exploring Multidimensional Conceptualization of Social Presence in the Context of Online Communities. *International Journal of Human–Computer Interaction*, *24*(7), 722–748. https://doi.org/10.1080/10447310802335789

Short, J., Williams, E., & Christie, B. (1976). *The Social Psychology of Telecommunications*. John Wiley and Sons Ltd.

Singhal, S., & Neustaedter, C. (2017). BeWithMe: An Immersive Telepresence System for Distance Separated Couples. In *Companion of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing* (pp. 307–310). New York, NY, USA: ACM. https://doi.org/10.1145/3022198.3026310

Singhal, S., Neustaedter, C., Ooi, Y. L., Antle, A. N., & Matkin, B. (2017). Flex-N-Feel: The Design and Evaluation of Emotive Gloves for Couples to Support Touch Over Distance. In *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing* (pp. 98–110). New York, NY, USA: ACM. https://doi.org/10.1145/2998181.2998247

Slater, M., Spanlang, B., Sanchez-Vives, M. V., & Blanke, O. (2010). First Person Experience of Body Transfer in Virtual Reality. *PLOS ONE*, *5*(5), e10564. https://doi.org/10.1371/journal.pone.0010564

Spence, C., Kingstone, A., Shore, D. I., & Gazzaniga, M. S. (2016). Representation of Visuotactile Space in the Split Brain. *Psychological Science*. Retrieved from http://journals.sagepub.com/doi/abs/10.1111/1467-9280.00316

Stafford, L. (2004). *Maintaining Long-Distance and Cross-Residential Relationships*. Routledge.

Stafford, L., & Canary, D. J. (1991). Maintenance Strategies and Romantic Relationship Type, Gender and Relational Characteristics. *Journal of Social and Personal Relationships*, *8*(2), 217–242. https://doi.org/10.1177/0265407591082004

Stafford, L., Merolla, A. J., & Castle, J. D. (2006). When long-distance dating partners become geographically close. *Journal of Social and Personal Relationships*, *23*(6), 901–919. https://doi.org/10.1177/0265407506070472

Tsakiris, M. (2010). My body in the brain: A neurocognitive model of body-ownership. *Neuropsychologia*, *48*(3), 703–712. https://doi.org/10.1016/j.neuropsychologia.2009.09.034

Appendix A.

Poster for Participants Recruitment

Comparing Social Presence and Body Ownership in Shared Video Chatting for Long-Distance Couples

Call for Participants

Get $20 Cash!

We are researchers from SIAT that want to help couples maintain connectedness through a new video chat system. You and your partner will do some simple tasks with Google Cardboard. **And you will get $20!** (You have to be at least 19 years old)

Date: Nov. 18 to Nov. 28

Location: SFU Surrey Campus

Length: 60 minutes

Compensation: $20 for a couple

Email us to schedule a study time!

Ray Pan: [redacted]

SFU
SIMON FRASER UNIVERSITY

Appendix B.

Email for Participants Recruitment

Hi, SIAT friends,

Do you wanna try a new way to video-connect your loved partner and get $20?

I am a Master student at SIAT and planning to run a study on a new video chat system that could help couples feel "seeing through my partner's eye". Sounds exciting right?
You and your partner will be invited to SFU Surrey campus for a 50 minutes study. All you need to do is sitting in a room and wear a Google Cardboard with mobile phone to do three simple tasks with your partner in different interfaces. Many participants said it was a whole new experience and it was fun!
The ideal dates of the study are from November 18 to November 28.
You can always contact me via email to schedule a time: [redacted]

Thanks,
Ray

Rui (Ray) Pan
MSc Candidate
Connections Lab, Simon Fraser University
[redacted]
http://clab.iat.sfu.ca
https://raypan.me

Appendix C.

Study Consent Form

School of Interactive Arts + Technology (SIAT), Simon Fraser University Surrey
250 -13450 102 Avenue, Surrey, BC V3T 0A3 Canada
Tel: +1 778.782.7474 Fax: +1 778.782.7478 Web: http://www.surrey.sfu.ca

SIMON FRASER UNIVERSITY

IAT 802: Quantitative Research Methods and Design
Informed Consent By Participants in a Research Study

Investigator Students of IAT 802: Quantitative Research Methods and Design
Course Instructor Bernhard Riecke, SIAT, http://ispace.iat.sfu.ca/riecke/

Any information that is obtained during this study will be kept confidential to the extent permitted by the law. Data will be retained at least for the duration of the project, and will be stored in secure locations like locked rooms and/or on password-secured storage devices. In cases where audio/video recording is used, this will only be done with the participants' consent. Knowledge of your identity is not required. You will not be required to write your name or any other identifying information on research materials.
Your signature on this form will signify that you have received a document that describes the procedures, possible risks, and benefits of this research study; that your are at least 19 years old; that you have received an adequate opportunity to consider the information in the documents describing the study – this information document will depend on the specific study you will be participating in; and that you voluntarily agree to participate in the study.
The University and those conducting this research study subscribe to the ethical conduct of research and to the protection at all times of the interests, comfort, and safety of participants. This research is being conducted under permission of the Simon Fraser Research Ethics Board (REB #2012c0022). The chief concern of the Board is for the health, safety, and psychological well being of research participants. Should you wish to obtain information about your rights as a participant in research, or about the responsibilities of researchers, or if you have any questions, concerns, or complaints about the manner in which you were treated in this study, please contact the Director, Office of Research Ethics by email at [redacted]a or phone[redacted]

Title: Synchronous Video Chat for Couples
Course project for IAT 802: Quantitative Research Methods and Design
Investigator Name (student researcher name): Rui Pan
Email of investigator where you can obtain research results once the study is finished:[redacted]
Investigator Department: School of Interactive Arts and Technology (SIAT), http://www.siat.sfu.ca/

Below is a description of what you will be asked to do in this study. Please do not hesitate to ask if anything should remain unclear:

Purpose and potential benefits of this study
We want to understand which interface among split, horizontal and overlapped view for a shared video chatting application called Ghost Partner is the best interface for long-distance couples to increase feeling of social presence and body ownership. The benefit of the study is to better understand the effect of a shared video view chat system and a comparison of the three interfaces for couples.

What you will be asked to do
You and you partner will try three different interfaces in a video chat app with Google Cardboard. There will be three tasks which involve hand movement and synchronous eye movement etc. Then you will be asked to fill a questionnaire and have a short interview with researcher. The total length of the study will be 50-60minutes.

Potential risks for you, for third parties or society
The major concern of the study is the possible discomfort caused by wearing Google Cardboards for long time. Expected risks would be motion sickness when participants wear the Cardboard and move too fast, where you could also experience slight fatigue. As soon as you should experience the onset of any adverse symptoms, you

are asked to immediately notify the experimenter, and the experiments will be stopped right away. There will be no consequences at all for withdrawing early from the experiment.

If you agree, we will video-record the exit interview. This would allow us to more easily analyze the interview later on and potentially use part of the video footage for scientific dissemination.

	Yes	No
1. Do you wish to be video recorded?	☐	☐
2. Do you wish to be audio recorded?	☐	☐
3. If you wish to be video and/or audio recorded, do you wish that your image/voice be distorted?	☐	☐
4. Do you permit the use of the video images and/or audio recordings in future research studies?	☐	☐
5. Do you permit the use of your video image and/or audio recording in public dissemination (thesis, papers, conference presentations, etc.) directly related to this research project? (NOTE: Due to the nature of digital video images, once the video image is disseminated to the public, the researcher does not have any control over how the images are distributed and/or used.)	☐	☐

Acceptance of this Form

I understand that I may withdraw my participation at any time without penalties. I also understand that I may register any complaint with the Director of the Office of Research Ethics or the researcher named above or with the Chair, Director, or Dean of the Department, School or Faculty as shown below. I have been informed that the research will be confidential. I understand the risks and contributions of my participation in this study and agree to participate:

Participant first name:_____ Participant last Name:_____

Participant Contact information (incl. email/phone):

Participant signature: _____ Date: _____

Appendix D.

Receipt of Participation

FACULTY OF COMMUNICATION, ART AND TECHNOLOGY
School of Interactive Arts + Technology

This receipt certifies that the persons named below received compensation $10 CAD.

for participation in a user study.

Printed Name: _____

Email Address: _____

Signature: _____

Date: _____

Appendix E.

Pre-Study Questionnaire

Pre-study Questionnaire

Participant No. _____ Date: _____

Gender: M F

1. How old are you?

2. What is your occupation?

3. How long have you been in relationship with your partner?

4. Have you been in Long Distance Relationship? If so, how far is it? How long is the LDR period?

5. Do you use video chat software to contact you partner? What software do you use? How often do you use the software?

6. Have you tried Google Cardboard or other Virtual Reality set (Oculus Rift, HTC Vive etc.) before? (6.2) If so, do you have motion sickness or discomfort when trying a Virtual Reality set?

Appendix F.

The 11-Item Questionnaire for Three Interfaces

Questionnaire (Horizontal view Interface)

Participant No. _____

Gender_____

Question 1: **I felt more connected to my partner compared to a normal video chat like Skype when using the horizontal view.**

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
○	○	○	○	○	○	○

Question 2: **I felt as if I was in the same room with my partner when using the horizontal view.**

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
○	○	○	○	○	○	○

Question 3: **I sometimes forgot about my partner and concentrated only on doing my own task when using the horizontal view?**

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
○	○	○	○	○	○	○

Question 4: **I could easily understand what my partner was doing when using the horizontal view.**

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
○	○	○	○	○	○	○

Question 5: **It was difficult for me to synchronize my movement with my partner when using the horizontal view.**

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
○	○	○	○	○	○	○

Question 6: **I felt like I was looking through my partner's eyes when using the horizontal view?**

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
○	○	○	○	○	○	○

Please flip to the other side ☺

Question 7: **I felt like I was with my partner just like doing our daily activities (such as having dinner together, doing exercise together)?**

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
○	○	○	○	○	○	○

Question 8: **I felt as if I had more than two hands when using the horizontal view.**

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
○	○	○	○	○	○	○

Question 9: **I felt as if my partner's hand changed to my hand when using the horizontal view.**

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
○	○	○	○	○	○	○

Question 10: **I felt like I was stroking my partner's arm in Task 3 when using the horizontal view.**

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
○	○	○	○	○	○	○

Question 11: **I felt like I was being stroked by my partner when using the horizontal view.**

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
○	○	○	○	○	○	○

Questionnaire (Overlapped view Interface)

Participant No. _____

Gender_____

Question 1: **I felt more connected to my partner compared to a normal video chat like Skype when using the overlapped view.**

○	○	○	○	○	○	○
Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree

Question 2: **I felt as if I was in the same room with my partner when using the overlapped view.**

○	○	○	○	○	○	○
Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree

Question 3: **I sometimes forgot about my partner and concentrated only on doing my own task when using the overlapped view?**

○	○	○	○	○	○	○
Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree

Question 4: **I could easily understand what my partner was doing when using the overlapped view.**

○	○	○	○	○	○	○
Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree

Question 5: **It was difficult for me to synchronize my movement with my partner when using the overlapped view.**

○	○	○	○	○	○	○
Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree

Question 6: **I felt like I was looking through my partner's eyes when using the overlapped view?**

○	○	○	○	○	○	○
Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree

Please flip to the other side ☺

Question 7: **I felt like I was with my partner just like doing our daily activities (such as having dinner together, doing exercise together)?**

○	○	○	○	○	○	○
Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree

Question 8: **I felt as if I had more than two hands when using the overlapped view.**

○	○	○	○	○	○	○
Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree

Question 9: **I felt as if my partner's hand changed to my hand when using the overlapped view.**

○	○	○	○	○	○	○
Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree

Question 10: **I felt like I was stroking my partner's arm in Task 3 when using the overlapped view.**

○	○	○	○	○	○	○
Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree

Question 11: **I felt like I was being stroked by my partner when using the overlapped view.**

○	○	○	○	○	○	○
Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree

Questionnaire (Split View Interface)

Participant No. _____

Gender_____

Question 1: **I felt more connected to my partner compared to a normal video chat like Skype when using the split view.**

○	○	○	○	○	○	○
Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree

Question 2: **I felt as if I was in the same room with my partner when using the split view.**

○	○	○	○	○	○	○
Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree

Question 3: **I sometimes forgot about my partner and concentrated only on doing my own task when using the split view?**

○	○	○	○	○	○	○
Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree

Question 4: **I could easily understand what my partner was doing when using the split view.**

○	○	○	○	○	○	○
Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree

Question 5: **It was difficult for me to synchronize my movement with my partner when using the split view.**

○	○	○	○	○	○	○
Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree

Question 6: **I felt like I was looking through my partner's eyes when using the split view?**

○	○	○	○	○	○	○
Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree

Question 7: **I felt like I was with my partner just like doing our daily activities (such as having dinner together, doing exercise together)?**

○	○	○	○	○	○	○
Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree

Please flip to the other side ☺

Question 8: **I felt as if I had more than two hands when using the split view.**

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
○	○	○	○	○	○	○

Question 9: **I felt as if my partner's hand changed to my hand when using the split view.**

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
○	○	○	○	○	○	○

Question 10: **I felt like I was stroking my partner's arm in Task 3 when using the split view.**

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
○	○	○	○	○	○	○

Question 11: **I felt like I was being stroked by my partner when using the split view.**

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
○	○	○	○	○	○	○

Appendix G.

Study Instruction

Study Instructions

1. Book the room, for each room, we need: a iPad, a chair, a tape, a heart shape sticker, a google cardboard with cell phone, Wi-Fi password.
2. Let them read the consent form and sign. (!!important)
3. Before running the study, ask the participants some questions about demographics. Then read this to them:

You will be using three different interfaces of a synchronous video chat system, which are split view, overlapped view and horizontal view. You will be doing three small tasks for each interface. The first task is to align a heart shape, the second task is to use your hand to form three English letters with your partner. And the final task is to use your right hand to stroke your left arm while you can see your partner doing the same. After all three tasks, you can play with the interface and explore your surroundings with your partner for 3 minutes. Don't worry I will let you know when to do it via the skype speaker☺

4. Guide them to the room for each participant, set up the skype channel and video recording. Let them sit on the chair and facing the paper on the wall. Turn on the volume of skype and start recording.
5. Use the audio of skype to inform them what to do for each task. When they feel they finish the task, ask them to raise their hand or say "I completed the task".

Manuscript:

Hi hello, can you hear my voice? Welcome to the study room! I will send my instructions through the skype speaker to you while you are taking the experiments. Don't worry, if you have any problems like technical issues, feeling discomfort or any questions, please don't hesitate to tell me. Now, please adjust the strap of the cardboard to make sure you are feeling comfortable with the cardboard. You can also adjust the lenses

to have the most comfortable focus for your eyes.

Right now I am gonna switch to [INTERFACE NAME] (click the button on the console page), can you see it?

Okay, lets start our first task "Align the heart shape". Please try to make the heart shape on the wall overlapped perfectly with your partner. (or try to align the vertical line through the heart shape in horizontal view). Whenever you feel you successfully complete it, say "We did it!" loudly to me so I know you are awesome!

Excellent! Now the second task, I ask you to form three English letters with your partner using your hand. Don't forget to say "we did it" when you finish.

Cool! Now come to our third task. Please raise your left arm in front of your eyes. And make sure your arm had the same position in the view with your partner's to make them overlapped. (or aligned in Horizontal view). Okay, now please use your right hand to gently stroke your left arm synchronously with your partner. Awesome, good job. Please keep doing it until I say "stop". (wait a minute).

Then it's exploration session. (Three minutes.)

This round of test is done! Please put off the cardboard and relax. Please find a questionnaire with [INTERFACE NAME] (repeat again) on the table and answer the questions, thank you! (Make sure you flip to the other side to answer all the questions).

(Wait until participants finished the questionnaire) I will switch a new interface for you, this time the interface is [INTERFACE NAME]

(Go back to task 1 and repeat)

Appendix H.

Post-Experiment Interview Questions

Post-study Interview

Participant No. _____ Date: _____

1. How would you rank your preference of the three interfaces? Why?

2. Did you have any discomfort when using the three interfaces? Why?

3. Did you feel any social awkwardness during the study?

4. What do you like the best about today's video chat experience compared to existing video chatting systems like Skype and FaceTime? Why?

5. What did you do with your partner in the exploratory sessions? Why?

6. What moments did you feel connected with your partner? Why?

7. What parts do you like the least about today's experience?

8. What English letters did you shape with your partner? Why?

9. (AD-hoc questions based on their performance in the study) examples are: I saw you did…., why? How was the experience?

10. In overlapped view, which side did you see more? Which side you want to see more? Why?

11. In Task3, did you feel any moments that you were really touching your partner or touched by your partner?

12. Are you willing to use the system for future video chatting?

13. Anything else that you want to tell us about today's experience or about the system or experiment process?