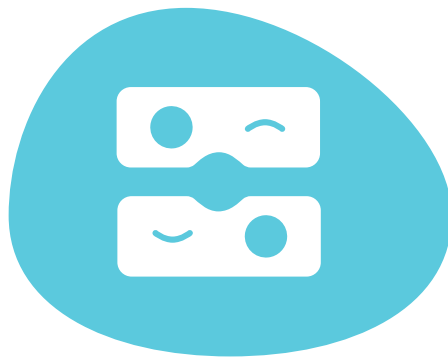


User Experience in Social Virtual Reality



Exploring methodologies for evaluating
user experience in social virtual reality

Exploring methodologies for evaluating user experience in social virtual reality

Master Graduation Thesis
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PREFACE

This graduation thesis is the final deliverable of the master graduation program Design For Interaction. It reports the outcome of a six-months research project: User Experience in Social Virtual Reality. This research based graduation assignment is part of the EU-funded project VRTogether (https://cordis.europa.eu/project/rcn/211093_en.html), which aims at offering novel virtual reality experiences based on social photorealistic immersive content. Centrum Wiskunde & Informatica (CWI) is one of the participants in this project. It is responsible for the research on both technology and user experience of social VR. This graduation assignment will address one of the tasks of CWI – understanding the different social aspects linked to social VR.

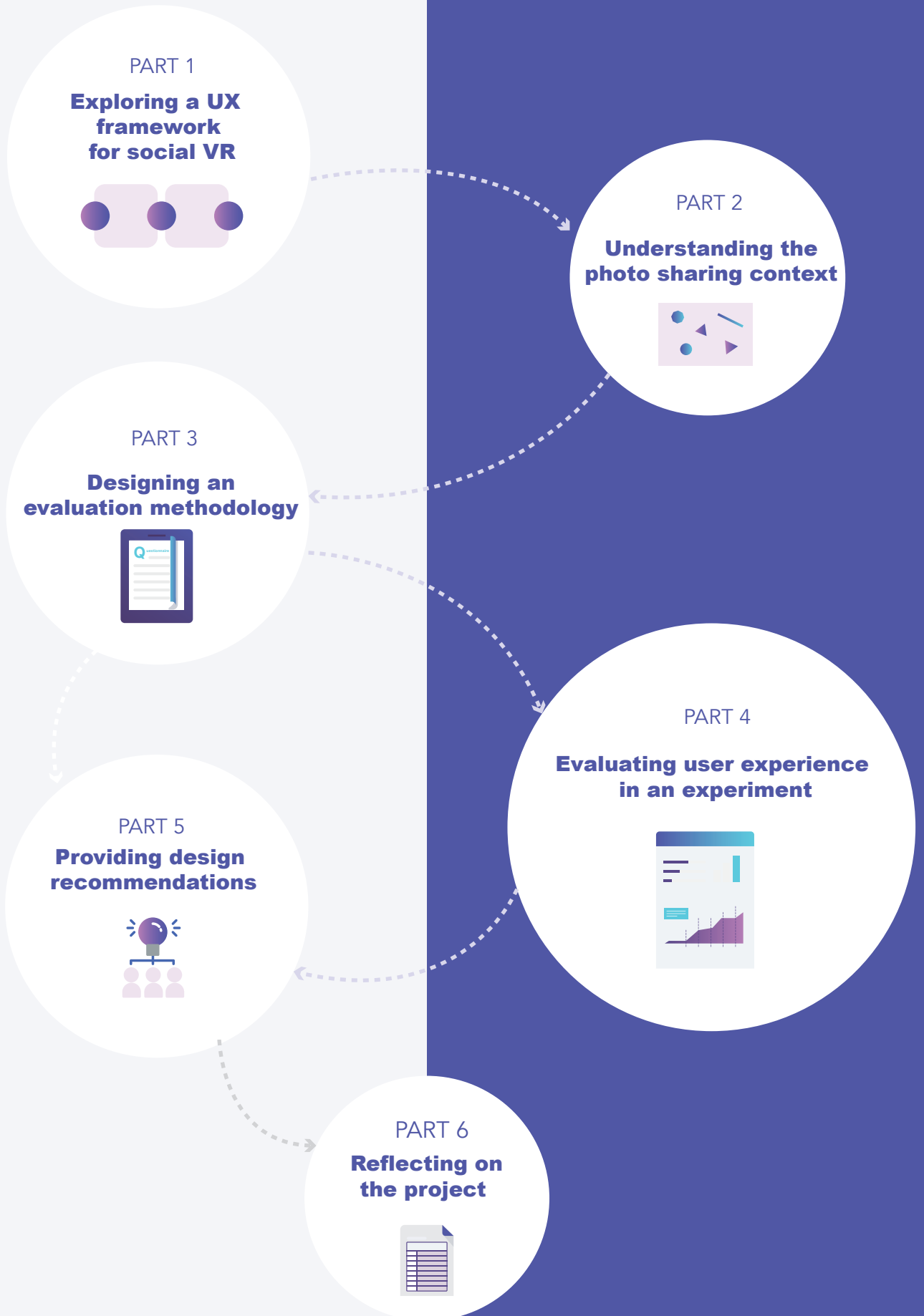
I would like to thank my supervisor team for the supporting and guiding during this graduation project. Huib, Pablo and Jie, working on this project with you three has been a great experience. Thanks for always giving me inspirations and insightful suggestions with patience.

Special thanks to Pablo for providing me support and all kinds of resources to complete the complex experiments, and being able to answer all kinds of questions. Special thanks to Huib for giving detailed and structured guidance for every little steps. I always felt inspired and motivated after conversations with you. Special thanks to Jie for contributing a lot of effort to the whole project and was always ready to help me.

Additionally, I would like to thank the Distributed and Interactive Systems (DIS) research group of CWI, thanks for your professional help during the process. Special thanks to Abdo, Francesca and Nacho, for helping me solve a lot of problems.

Finally, I would like to thank my family and my friends for being with me when I need help, cheering me up, giving great me courage. Thanks to all your supports, I was able to reach the destination of my graduation journey.

PROJECT PROCESS OVERVIEW



General - Social VR

Specific - photo sharing

EXECUTIVE SUMMARY

Nowadays, social interaction is often mediated by technology, which makes it possible for people to interact with each other when they are separated. However, most of these technologies target the interaction between 'weak ties' and they cannot support the naturalness and richness offered through face-to-face interaction. Recently, a new type of mediated social interaction technology, social VR, is opening new possibilities. Social VR technology allows users who are separated to interact with virtual representations of other people in shared virtual environments. These types of social VR technologies are believed to have the potential to create social interactions that are similar to face-to-face interaction. Although many systems are being developed, there is still a long way to go before social VR

technologies can be used commercially.

The first step is to better understand the user experience offered by social VR technologies. Efforts are needed to understand how people experience interacting with others in social VR. What are the advantages of social VR that make it different from other social medias, and how can these be used to improve mediated social interaction. These questions, if solved, will provide valuable insights for the development of new social VR products that bring values for both industry and end users. Regarding this knowledge gap, the problem defined in this project is to understand the impact of social VR on user experience during social interaction.

This project is divided into six parts: exploring a UX framework for social VR, understanding the photo sharing context, designing an evaluation methodology, evaluating user experience in an experiment, providing design recommendations and reflecting on the project.

While PART 1, PART 3 and PART 5 are about understanding the general user experience of social VR, the other parts focus on exploring the user experience in a specific scenario - photo sharing between two friends.

In **PART 1**, the user experience framework of social VR is explored. Several relevant frameworks are selected and compared. These frameworks help us to create a common ground understanding of user experience in social VR.

In **PART 2**, user experience is explored in a specific scenario - photo sharing between two friends. Context mapping is used to understand the important dimensions of user experience. Three dimensions of experience are identified: Quality of interaction, Social

meaning and Presence/immersion. This finding contributes to the development of an evaluation methodology in PART 3.

In **PART 3**, an evaluation methodology is developed according to the research findings in PART 2. This methodology consists of a quantitative part and a qualitative part. For the quantitative part, a questionnaire is developed, based on a set of questions selected from related work. For the qualitative part, a semi-structured interview is designed.

In **PART 4**, the evaluation methodology from PART 3 is used in an user experience experiment. We compare the experience of photo sharing in Social VR with a Face-to-face situation and a Skype situation. Pairs of participants who know each other joined the experiment.

In **PART 5**, design recommendations for social VR are proposed, based on the evaluation results from the experiment in PART 4.

In **PART 6**, reflections on the whole project are provided. Suggestions for future research are given.

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Project Organ Session

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with materials enabling them to interpret and explore practices to us. Finally, we wanted an approach allowed us to carry out an ongoing conversation with participants and through this conversation arrive at an understanding of intimacy and the place of mediating intimate acts. We describe this approach in the next section.

RESEARCH DESIGN

Other researchers who have had to confront investigating personal relationships have used a variety of research methods. These include: online surveys [3, 7]; data logs [14]; longitudinal interviews [18]; and written reflection [19]. We adopted a suite of methods and techniques.

Our research plan is represented in Figure 1. The first phase of our research we undertook was ethnographic studies using cultural probes [20] to understand how people use the insights into current relationships. In the second phase we used support intimate acts. In the third phase we used participative design to support the development of low-cost interaction in VEs.

Method

Our approach extended the Equator team [6] to include a collection of contextual interviews. The probe pack included a camera with digital and catch-phrases to support the diary.

1.1 Background

In the early 1990s, the dominant image of interactive technologies was of single-user head-mounted displays [1, 2]. Nowadays, there is a range of technologies projected onto several walls, projection technology (IPT) or CAVE-type walls [3], runs on desktop personal computers (PCs) and environment is projected onto several walls. Only since the mid-1990s, with the advent of internet-based shopping malls, churches, and hundreds of thousands of participative systems being developed, there are dozens of internet-based shopping malls, churches, and hundreds of thousands of participative systems being developed. The world that aim to develop

Figure 1. Cycle of use-centered innovation [16]

(phase 2)
participatory design,
prototype implementation

Image
Future
Practice

In a virtual world, and smart technologies, and different studies, and implications, and be brought to bear on interaction in VEs.

PART 1 EXPLORING A UX FRAMEWORK FOR SOCIAL VR

This part starts from introducing the background of mediated social interaction. The current state of social VR technology is explained. After that, the definition of user experience and related frameworks for social VR are explored. Several relevant frameworks are selected and compared. These frameworks help us to create a common ground understanding of user experience in social VR.

1.1 BACKGROUND



- Importance of face-to-face interaction
- Social virtual reality

1.2 USER EXPERIENCE FOR SOCIAL VR



- User experience definitions
- User experience frameworks
- Influence factors
- User experience for social VR

1.1 BACKGROUND

Importance of face-to-face interaction

Numerous individuals live apart from someone whom they care about, such as their lover, friend, parent, child, or other relationships [21]. For these long-distance relationships, maintaining the intimacy becomes a challenge. Since they have limited access to face-to-face interaction, social media such as Whatsapp and Facebook are used to interact with each other when they are separated by time and space.

Despite of the convenience of social media, they have certain drawbacks regarding maintaining relationships. First, most of these technologies target the interaction between 'weak ties', which can not match the interaction requirements for maintaining 'strong ties' [8]. Second, the use of social media influences normal social interactions. Research shows that increase of online social interaction plays an important role in decreasing communication between families and developing negative consequences such as, depression and loneliness [16,17]. Therefore, it is suggested that social media can only be used as a complement to face-to-face interaction, not as a substitute [18]. Another drawback is that social

media does not support the sense of closeness. Baym et al. [20] found in a survey with 496 participants that people were more likely to use face-to-face interaction in more intimate relationships, and the internet did not get that boost from closeness. **Therefore, face-to-face interaction is still an essential part of maintaining interpersonal relationships, especially for 'strong ties'.**

Face-to-face interaction is defined as the mutual influence of individuals' direct physical presence with his/her body languages [19]. This type of interaction makes relationships to be emotionally close and have shared meanings. A basic requirement for face-to-face interaction is being physically located in the same place, which becomes a barrier for long-distance relationships. Recently, a new type of mediated social interaction technology, social virtual reality (social VR), is opening new possibilities. This new technology brings people separated in space together in a same virtual world to interact with each other. It is believed to be able to bridge the gap between mediated social interaction and face-to-face interaction by supporting natural interactions and bringing the sense of closeness.

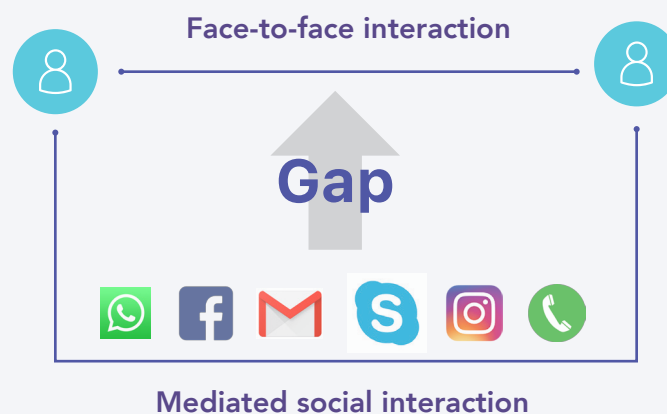


Fig 1 The gap between mediated social interaction and face-to-face interaction

Social virtual reality

Social VR technology allows users separated in space to interact with virtual representations of other people in shared virtual environments. The form of virtual representations varies. For example, the Facebook Space (<https://www.facebook.com/spaces>) renders users' real time movements onto 3D avatars. The technology from TNO projects photorealistic virtual representatives in the virtual environment [44]. Fig 2 shows some examples of social VR technologies. These types of social VR technologies are believed to **have the potential to create social interaction similar to face-to-face interaction**.

However, how people experience interacting with virtual representative, and to what level can social VR simulate the experience of face-to-face interaction remains to be

understood. Is it just as good as 'being there', or maybe even better? Previous research [22, 23, 24] founds that avatar realism is a basic requirement for social presence. Several aspects of behavioral realism, such as head movement, eye movement and hand gesture are found to have positive effect on immersive interaction. Smith et al. for example, found that social VR and face-to-face interaction show remarkably similar verbal and nonverbal communicative behavior, and that there is no significant difference in terms of social presence [23].

Successful design of social VR products requires insights into the user experience that take place while using the products. However, currently there are no systematic evaluation methodologies for social VR user experience. Exploring the right methodologies is an urgent task.



Facebook Space - Avatar based social VR



vTime - Avatar based social VR



TNO demo - Photorealistic social VR

Fig 2 Three examples of social VR technologies

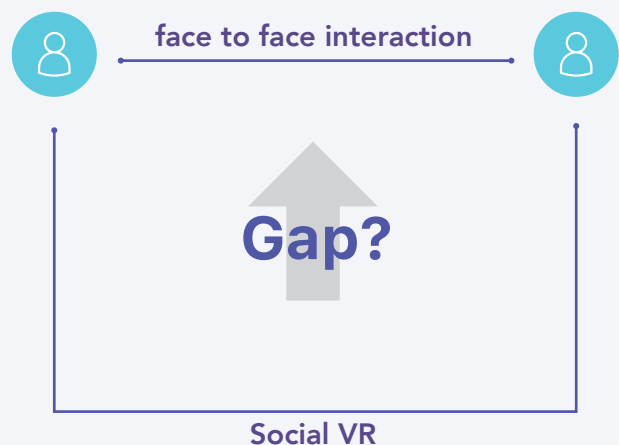


Fig 3 The gap between social VR and face-to-face interaction

1.2 USER EXPERIENCE FOR SOCIAL VR

User experience definitions

User experiences happen based on a complex interplay of aspects and processes such as: product interaction, the user's sense-making of this interaction, the user's predisposition and the context.

According to ISO 9241-110:2010 (clause 2.15), user experience is defined as: 'a person's perceptions and responses that result from the use and/or anticipated use of a product, system or service' [45]. However, this definition is not sufficient when we take interpersonal communication into consideration. The development of interpersonal communication technologies has put emphasis on the social aspects of user experience. This user experience cannot only be seen as an individual's reaction, but also as something constructed when interacting socially. Katja et al. therefore created a definition for 'co-experience' as the experience that users create together in social interaction [46]. The definition of user experience in mediated social communication is 'the various types of experiences people have when using the system, product or service for social communication [11]. For virtual environments, the emphasis of user experience is on the ability to produce a sense of presence, or 'being there' [47].

Although a commonly accepted definition of user experience for social VR cannot be found, these related research from the field of mediated social communication and virtual reality help to create an initial common ground of understanding.

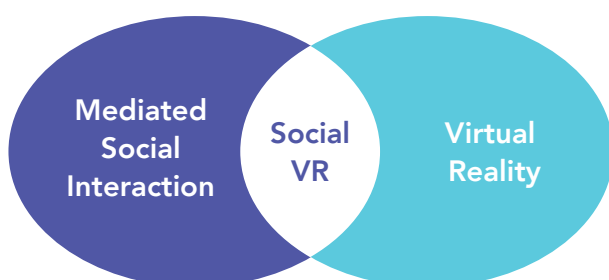


Fig 4 The relationships among the three fields of research

User experience frameworks

Research has also been done to understand what dimensions of experience are important for mediated social interaction. According to Steen et al., experience of mediated social interaction can be divided into three categories: 1) Aesthetics: people's experiences of the sensorial qualities of the system that enables social communication; 2) Interacts: people's experiences of interacting with the system and with others via the system; 3) Meaning: people's experiences of social communication in the broader context of daily life [11]. These three types of experience also correspond to the three groups of UX evaluation methods: Sensory characteristics, Emotional reactions and Meaning [48]. On the other hand, the important dimensions of experiences in virtual reality have also been discussed in the literature. According to Heim [49], who defined VR with 'three I's', the three characteristic of VR are immersion, interactivity and information intensity. Apart from that, Steuer et al. also defined virtual reality based on the concept of 'Telepresence', and the two dimensions of experience were vividness and interactivity [50].

Although the dimensions of experience mentioned in the frameworks above varied from one another, there are some interesting overlaps. For example, the user experience is general divided into three dimensions [11, 48, 49], the dimension of social meaning is mentioned twice [11,48], and the dimension of interactivity is mentioned three times [11, 49, 50].

Since there are no commonly accepted user experience frameworks for social VR, the frameworks from the field of mediated social communication and virtual reality, as mentioned above, can help us to propose a list of important dimensions of user experience in social VR.

Influence factors

The user experience mentioned above is influ-

enced by many factors.

First of all, it is shaped by the ways in which people interact and communicate in the social relationships, known as social interactions [11]. Desmet indicated that interaction influence experience. He defines product experience as 'the entire set of affects that is elicited by the interaction between a user and a product' [12]. Forlizzi and Ford presented a model of user experience in interaction, showing that experiences are momentary constructions that grow from the interaction between people and their environment [62]. In this model, experience depends on people's actions and encounters in the world. Battarbee et al. also argued in their research that 'an interaction-centered view is the most valuable for understanding how users experience designed products.' They divided experience into three dimensions according to different

interactions that yield them [63].

The studies mentioned above suggest that the way people interact with the product has strong impact on the experience that is elicited by the interaction. Understanding different types of interactions even helps to classify different dimensions of experience.

On the other hand, **the interaction and user experience discussed above are influenced by three factors, known as system factors, human factors and context factors** [15]. System factors stand for the design of the system, which can be controlled by designers. Human factors are about the users' background. While context factors stand for the context in which social interactions happen. All of these influence factors need to be taken into consideration before we evaluate the user experience.

User experience for social VR

As shown in Fig 5, the insights from the relevant user experience research were considered and used to create a common ground understanding of social VR user experience. (This chart only applies to situations of two persons interacting with each other. Multiple-user situations will be explored in future studies.)

There are three types of influence factors: context, user and system. The context factors are determined by the context of social occasions. And the user factors are about the background of the user. The system factors are

about how the system is designed and how it can be used. In this project, the system factor is about how the social VR system is designed. These factors influence the way user interact with the social VR system, which has a great impact on user experience.

In the following parts (PART 2, 3, 4, 5) of the project, this understanding of user experience will be used as a guideline. It helps to evaluate the user experience of social VR in a specific scenario: photo sharing between two friends. And finally in PART 6, a reflection on this framework will be reported based on the learnings.

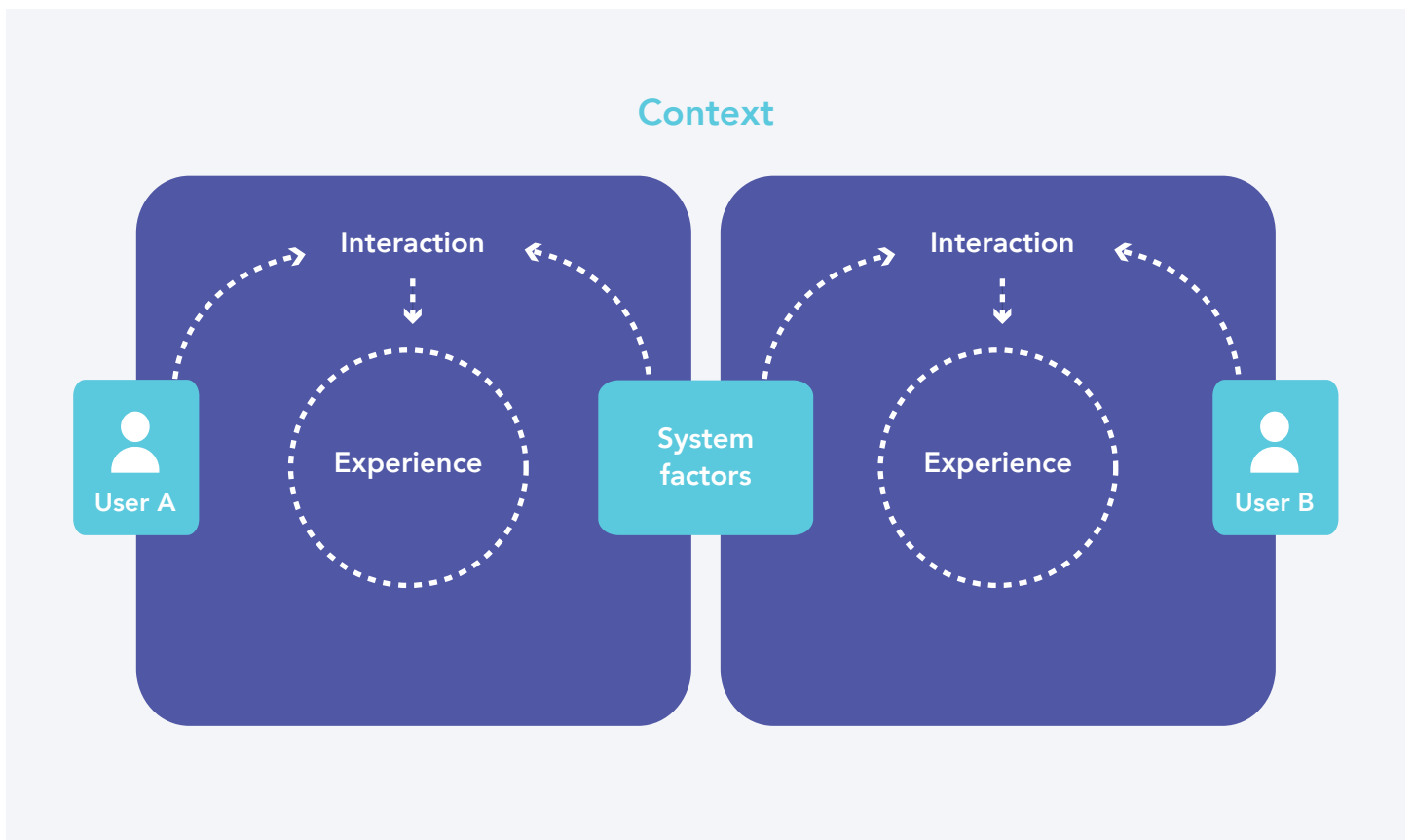


Fig 5 The common ground understanding of social VR user experience, created based on literature research



PART 2 UNDERSTANDING THE PHOTO SHARING CONTEXT

In this part, the user experience of social VR is explored in a specific scenario: photo sharing between two friends. In order to understand what are the important categories of experience, context mapping is performed. An interaction-centered methodology helps to cluster the experience into three dimensions of experience: 'quality of interaction', 'social meaning' and 'presence/immersion'. The findings of this part will be used as input for developing an evaluation methodology in PART 3.

2.1 INTRODUCTION



2.2 PHOTO SHARING



2.3 CONTEXT MAPPING



2.4 FOCUS GROUP



2.5 CORRESPONDENCE ANALYSIS



2.1 INTRODUCTION

This part focuses on identifying the important dimensions of experience. In order to do that, a specific scenario - 'photo sharing between two friends' is selected. This scenario is selected because it represents one of frequent interactions between close relationships, and it happens both face-to-face and online. More explanations for choosing this scenario can be found in part 2.2.

The structure of this part of research is shown in Fig 6. Based on the selected scenario, context mapping with users is firstly conducted to understand how do people usually share photos face-to-face. It provides us with insights about the basic information of photo sharing, important categories of experience and a flow

of actions.

Secondly, a focus group with a group of experts is conducted to analyze the social interactions that might influence the user experience. A list of important interactions is found.

Finally, a correspondence analysis is performed to group the categories of experience. The analysis is performed based on the relationships between different categories of experience and interactions, indicated by 20 user experience designers. Three dimensions of experience are identified from the analysis: 'quality of interaction', 'social meaning' and 'presence/immersion'.

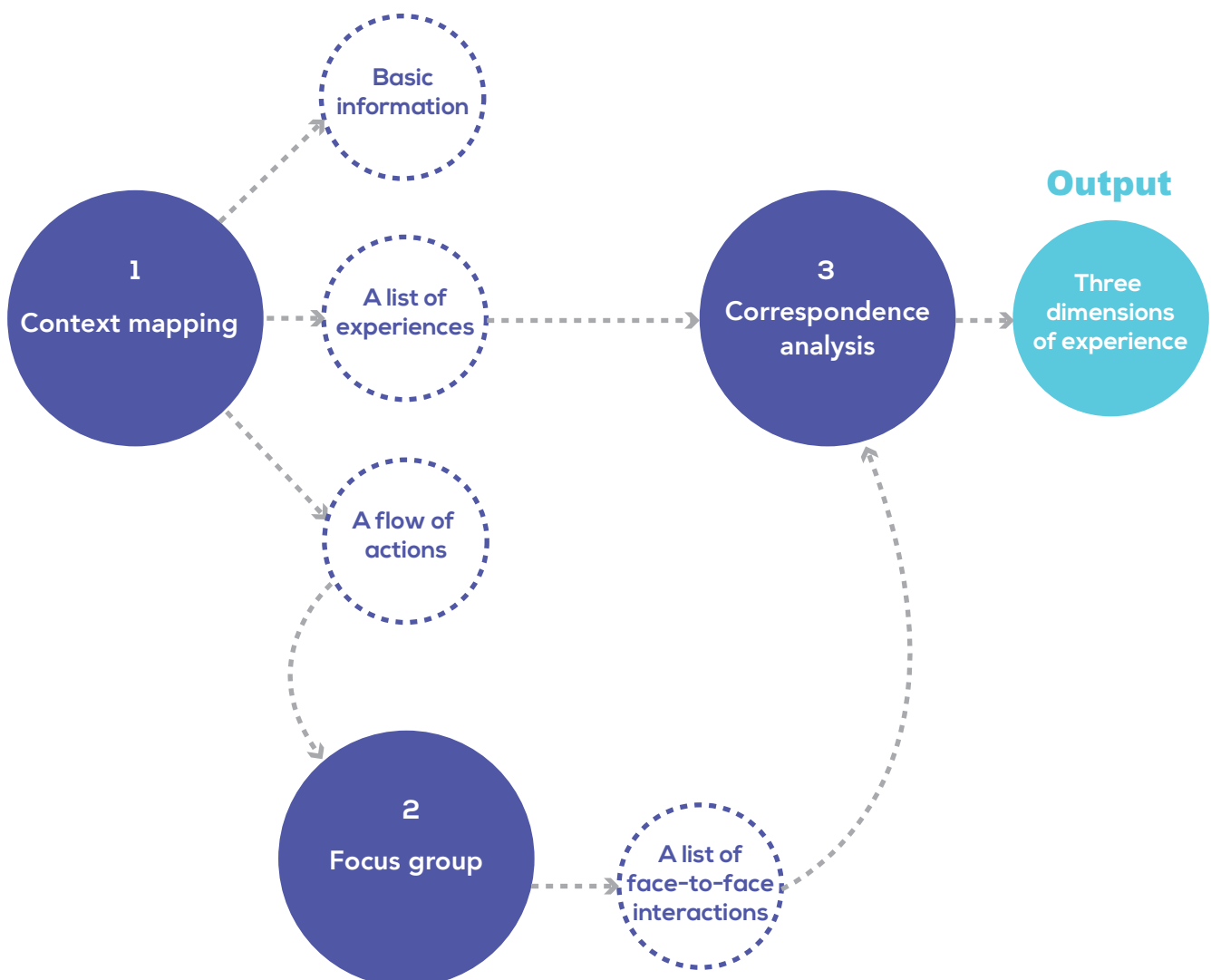


Fig 6 The structure of user research in PART 2

2.2 PHOTO SHARING

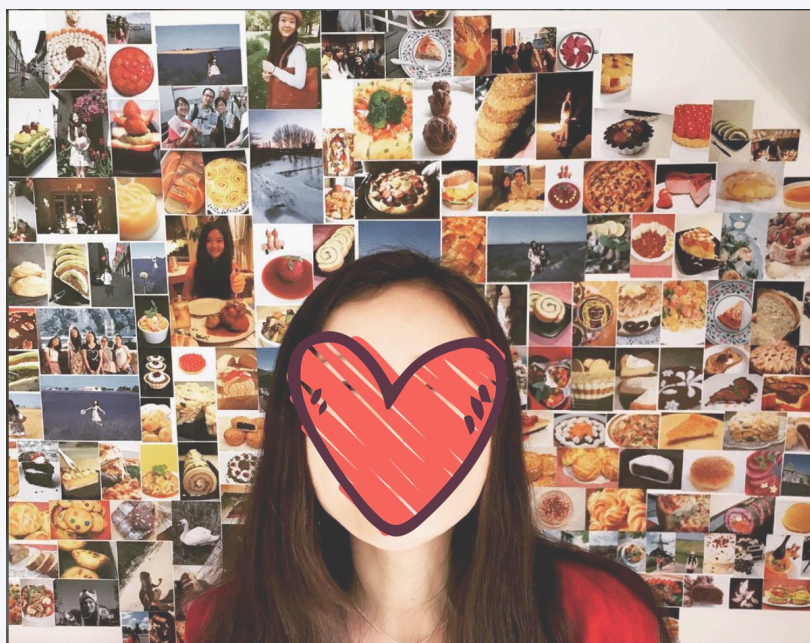
Photo sharing as a representative use case

The universal use of smart phones encourages frequent and spontaneous photo taking of ordinary things. Everyone is in some way affected by personal photography – as photographer, subject, or viewer. Personal photography is of great importance to the record of important life events, of family members, of travel, and of daily life [51].

Why do people take photos? Kindberg et al. indicated that the intentions of people taking photos vary along two dimensions: social versus individual intentions, and affective versus functional intentions [57]. The social intentions of photo taking have received much research attention. Okabe distinguished two patterns of camera phone usage for social intentions: 1) sharing photos with close friends and families who are not present at the time the photo is taken; 2) capturing and sharing

photos of events that are considered noteworthy [56].

Photos can be very important in social relationships. **Sharing photos and telling stories is a way of keeping up with each other's lives, which helps nurture relationships** [51]. Van House et al. explained that photo sharing help creating and maintaining social relationships because it supports: 1) constructing personal and group memory; 2) self-presentation; 3) self-expression [51]. Makela et al. found that photo sharing is an important flow of everyday life, because it allows family members to keep up on one another's life events [55]. Biemans et al. found in an experiment that 80% of the photos were sent to keep awareness of families and friends for everyday life, creating a sense of social connectedness [58]. Therefore, in terms of maintaining close relationships (families and friends), photo sharing is a representative activity.



Copresent photo sharing

Apart from sharing photos face-to-face, there are many other options to share photos. Frohlich divided different types of photo sharing into four categories (as is shown in Fig 6) according to time and location. And he did research into each category about how people experience photo sharing [2].

	SAME TIME	DIFFERENT TIME
SAME PLACE	Prints Slides & projector CO-PRESENT SHARING <i>Photo viewing software & devices</i>	Shoeboxes Albums & frames ARCHIVING <i>CD-ROM</i> <i>PC filestore</i> <i>Photo website</i>
DIFFERENT PLACE	Telephone REMOTE SHARING <i>Application sharing</i> <i>Instant messaging</i> <i>Video conferencing</i>	Mail SENDING <i>Email attachment or website reference</i> <i>Internet photo frames</i>

Fig 7 Different forms of photo sharing divided by Frohlich

Most of these digital images are uploaded to websites such as Flickr or social medias such as Facebook. These shared photos are reviewed by other people at different time and location, and sometimes they will give comments and ratings. However, these simple interactions usually do not allow the photographer to communicate the experience, which is believed to be the main reason for sharing photos [1]. Vronay [3] and his colleagues also found that **compared with face-to-face photo sharing, sharing photo online does not convey the emotion and storytelling.** In Frohlich's user

research, it was reported that participants were "turned off" by looking at digital photographs on a computer screen when sharing with families and friends because they lacked the tangibility and manipulability of physical photographs [2].

Many researchers acknowledged that **the meaning and value of a photo is delivered through having a conversation around it. The conversation helps to deepen interpersonal relationships** [1,2]. Nancy et al. [4] found that copresent sharing remains important in a digitally-mediated world. Copresent sharing was also proved by Frohlich to be the most enjoyable method, and it was seen as a way of recreating the past and reliving the experience with others [2].

Copresent viewing is a dynamic, improvisational construction of a contingent, situated interaction between the story-teller and the audience [4]. A lot of face-to-face interaction happens during this process. In Duncan's study, face-to-face interactions can be divided into many categories: paralinguage, body motion, proxemics, use of scent, haptics and artifacts [14]. Most of previous studies have focused on the oral interaction for copresent photo sharing, and the influence of other forms of interactions still need to be explored.

Therefore, in this project, I am going to select 'copresent photo sharing' as a specific scenario. By investigating into various types of interactions and different dimensions of experience that happen during photo sharing, we can have an initial understanding of social VR user experience.

2.3 CONTEXT MAPPING

Research questions

1. "How do people share photos face-to-face (what, whom, where, how)?"
2. "What are the important categories of user experience in this scenario?"

Methods

This study is conducted in the form of context mapping [27]. The aim is to gain deep insights into the context of face-to-face photo sharing, and map out three types of information: 1) basic information of photo sharing; 2) a list of important categories of user experience; 3) A flow of actions. The findings from this part will be used in the focus group and correspondence analysis.

Participants

10 participants were recruited, 50% male and 50% female. The age of the participants ranged between 22 and 35. The participants were students from TU Delft with varied nationalities (Chinese, Dutch, Mexican). All of them had experience in sharing photos face-to-face with friends and families.

Process

Context mapping was conducted in the following phases, as proposed by Sleeswijk [27].

Preparation

Based on the research goals, a plan of context mapping was created. A sensitizing booklet was designed and participants were recruited.

Sensitization

Participants were sensitized and prepared for the group session in this phase. Each of them was asked to fill in a booklet about their photo sharing experience. After filling out the booklet, individual interviews with open questions were conducted.

Fig 8 shows the two parts of the sensitizing booklet. Detailed booklet design can be found in Appendix 1. In the first part, participants provide general information related to the form of the photos, people with whom they

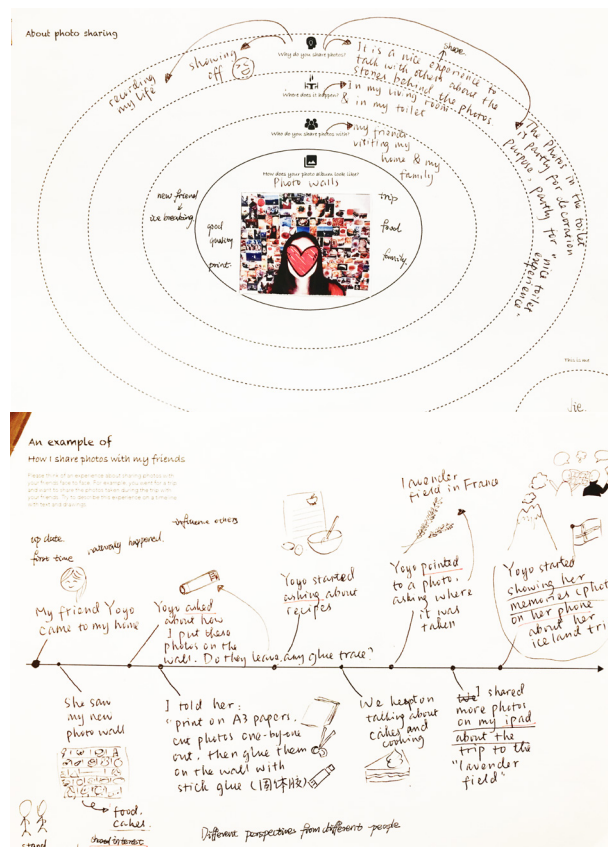


Fig 8 An example of sensitizing booklet for context mapping

share photos, locations of photo sharing and triggers of photo sharing. In the second part, participants described a detailed photo sharing experience.

Group session

One week after the sensitizing phase, participants were invited to a group session, which lasted around 50 minutes. After signing the consent form, they shared their booklets with each other and discussed their experience (20 minutes). Then they were asked to make a drawing of ideal photo sharing experience and present it to each other (30 minutes). Fig 9 shows the setup and procedure of the group session.

Analysis

The analysis of qualitative data followed the 'three steps guideline' [27].

Step1: 'Fixate on the data': All the booklets and drawings were collected, the interviews and sessions were audio recorded and transcribed to establish 'a trail of evidence' [28].

Step2: 'Search and be surprised': Two researchers read through all the materials. Interesting contents were marked with short explanation phrases on sticky notes.

Step3: 'Find patterns and create an overview': All the selected contents were divided into three groups, the first is about general information, the second about categories of experiences, and the third about a flow of actions.

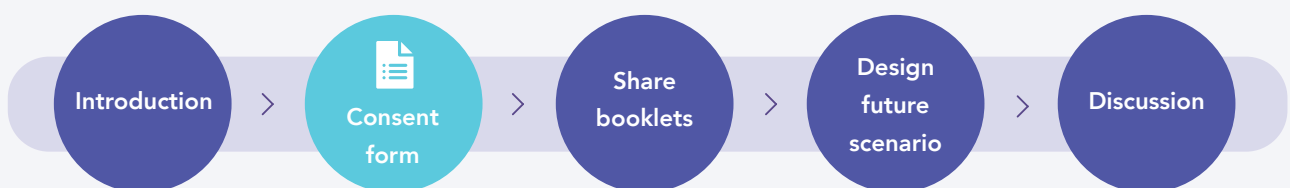


Fig 9 The setup and procedure of the group session for context mapping

Results

The results of context mapping can be divided into three parts. Each part will be explained here.

Part 1 - General context information

This part of results helps us to understand the activity of photo sharing in general. This information will be used later for designing the experiment setup.

- About the forms of photos

They share photos either digitally or physically. Digital photos are usually displayed on mobile phones. Physical photos can be displayed in many forms, such as a photo wall, photo frames or photo albums. Even though physical photo sharing experience were mentioned many times, participants indicated that digital photo sharing is the most convenient and frequent way of sharing. The contents of the photos various a lot, and they are usually about people they know, food and travel.

- About with whom

The face-to-face photo sharing usually happens with friends, families and guests, mostly with people they know well.

- About the locations

With physical photos, the sharing usually happens at home. However, with digital photos, the sharing can happen anywhere, such as in a restaurant or during a party. Sitting side-by-side is mentioned as a common position when doing photo sharing.

- About the triggers

There are various triggers for starting photo sharing, such as sharing experiences, answering questions and starting a conversation.

Fig 10 shows an overview of the information collected from the booklets. These findings helped the experiment design in PART 4. For example, pairs of two people who know each other well were recruited. The digital form of photo was selected, and the contents of photo were decided by the participants.

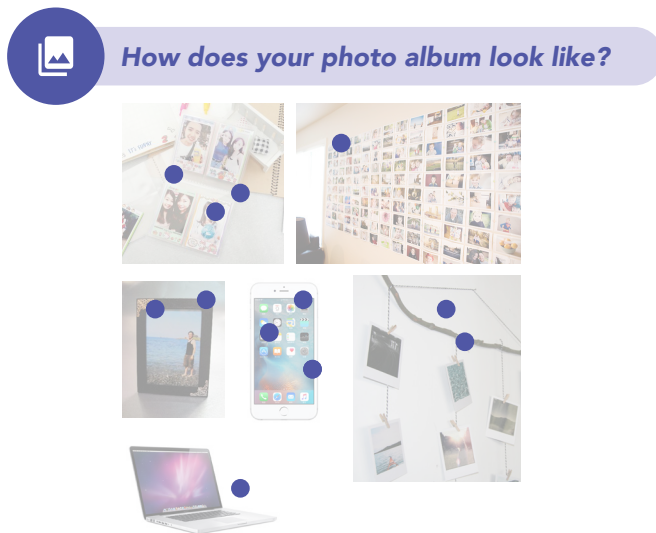


Fig 10 The findings of photo sharing from context mapping, dots stand for the number of mentioned times

Part 2 - Important categories of experience

The transcripts related to the experiences were marked and written on sticky notes. Two researchers together clustered the experiences into several categories. 12 categories of experience were found, shown in Fig 12. The original data of the 12 categories can be found in Appendix 2.

These categories of experience are considered by the participants to be important for photo sharing. Based on these categories, I want to further explore their internal relationships and identify patterns. Correspondence analysis is therefore performed in section 2.5.

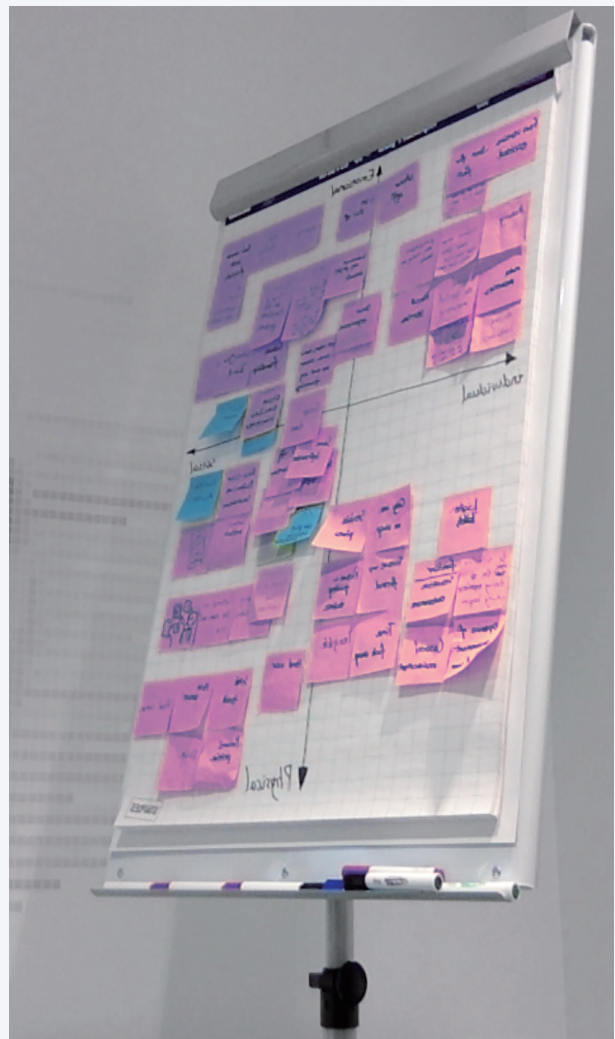


Fig 11 User experience analysis process

Real sense

"I want to feel that I am together with my friend."



Tangibility of photo

"I want to touch and hold the photos."



Engaging conversation

"I want to have real-time responsive conversations."



Feel the emotion

"I want to see my friend's expressions and understand his emotions."



Understood by others

"I want my friend to understand what I am talking about."



Conversation triggers

"The objects in the environment can inspire me to start interesting conversations."



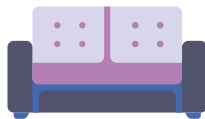
Have fun

"I want to enjoy the time spent with my friend."



Relaxed environment

"I want to feel relaxed when sharing photos."



Show off

"I want to show off my experiences."



Create stronger bond

"The photo sharing enhances our relationship."



Have same focus

"I want both of us to focus on the same thing."



Recall and reproduce memory

"I want to share my memories with my friend."



Fig 12 Visualization of different categories of experience

Part 3 - A flow of actions

The specific experience timelines made by participants in the sensitizing booklet were analyzed to create a general user flow of sharing photos. Actions mentioned in the timeline were marked. Fig 13 shows an example of how actions are marked. Details of analysis can be found in Appendix 3. All the actions from 10 timelines were put together into one general user flow. 5 stages were identified in this flow.

- Being together

The users are together with their family or friends in the same location. The location can be at home, in a party or in a restaurant.

- Trigger

Normally, the photo-sharing activity does not happen intentionally, but it happens with a trigger. The trigger can be someone pointing a picture on the wall, a question that requires visual input, mentioning an experience or searching for fun topics. These events trigger

the two people to share photos with each other.

- Sharing

One people starts to tell the story behind the photo. He can either hand over the photo or watch the photo together with the other person, making sure that they both know the content being discussed.

- Discussion

The sharing of the story is followed by further discussions.

- Development

After the discussion of one photo, another trigger of photo sharing might happen and they start another round of photo sharing. This process continues till the end of sharing. Other topics might appear and replace the photo-sharing process.

This flow will be used as an input for the focus group in 2.4.

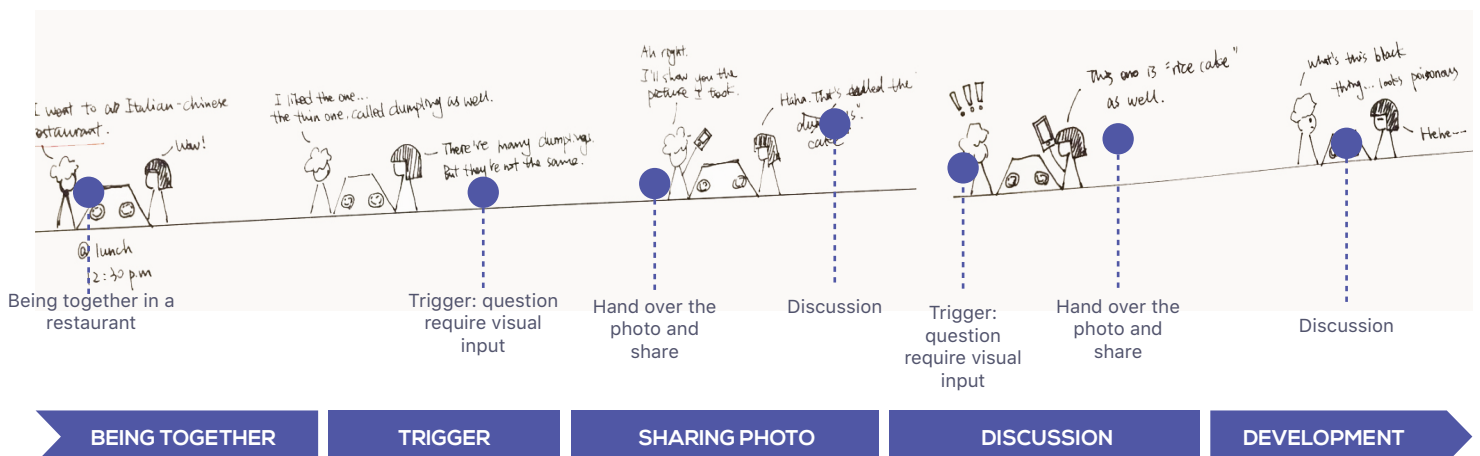


Fig 13 An example and the result of action flow analysis

2.4 FOCUS GROUP

Research questions

“What social interactions happen during each phase of photo sharing?”

Methods

This study followed the focus group method, as described by Krueger [29]. The aim is to get collective insights on social interactions that happen during face-to-face photo sharing. Results from the context mapping (the flow of action) is used as input.

Participants

A mini group of 6 participants was selected. They are experts in the field of social VR, with varied occupations (designer, researcher, developer). The age of the participants ranged between 25 and 50. All of them are interested in face-to-face photo sharing.

Process

Preparation

A presentation with background information and a list of questions were created. Materials to be used during the focus group were prepared.

Group discussion

Participants first signed consent forms. Then they watched a presentation introducing the photo-sharing scenario. The concept of face-to-face interaction was also introduced. Then they were given a first small task to generate as many interactions between two people as possible.

After that, the user flow of photo sharing was shown and they were asked to select the interactions that will happen during this flow. Extra interactions that came to their mind were allowed to be added.

After this, they started to vote for the interactions that are important for user experience in this scenario. A list of important interactions

was identified. Fig 14 shows the process of the focus group session.

Analysis

The cluster of interactions made by participants during the group session was collected, the whole process was video recorded.

Two researchers went through all the selected interactions and counted the votes that they received, the data can be found in Appendix 4. Interactions with more than one vote were selected and further grouped according to the researcher’s interpretations and Starkey’s face-to-face interaction theory [14].

Results

The detailed results can be found in Fig 15. 20 types of interactions that received more than 3 votes were identified. The top six types of interactions are: 1) way of speaking, 2) body posture, 3) listening to same music, 4) eye contact, 5) pointing and 6) facial expressions.

With an interaction-centered view, the following research (section 2.5) will use the relationships between the 20 types of interactions and 12 categories of experience to further cluster the user experience and identify patterns.



Fig 14 The setup and procedure of the focus group



Fig 15 Different groups pf interaction (different colors represents different parts of body)

2.5 CORRESPONDENCE ANALYSIS

Research questions

“What are the relationships among 20 types of interactions and 12 categories of experience?”

“How can the categories of experience be further grouped?”

Methods

As discussed in section 1.2, an interaction-centered view is the most valuable for understanding how a user experiences a designed product. [63] Understanding different types of interactions can even help us to classify different dimensions of experience. Therefore, in this study, we use correspondence analysis to help us further cluster different categories of experience into major groups, based on their relationship with different types of interactions. The analysis method, as described by Hirschfeld [32] was used here. This method helps to display a set of data in a two-dimensional graphical form, which helps to visually classify different information into groups.

Data source

The list of 12 categories of experience from context mapping (section 2.3) and the list of 20

types of interactions from focus group (section 2.4) are used as two variables. Each pair of experience and interaction was rated for their relationship in an online questionnaire, done by 20 user experience experts. Fig 16 shows one example of the questionnaire results.

The user experience experts are master students studying at interaction design, with more than 3 years of experience in the field of user experience design. 14 females and 6 males finished the questionnaire, their age are mostly from 20 -30 years old.

Data processing

The categories of experience were put into SPSS as columns and the types of interactions were put as rows. For each pair of experience and interaction, the score of relationship was also put into SPSS. After that correspondence analysis was performed. Two-dimension scale was chosen (explaining 53.3% of Inertia). The ‘Chi square’ was selected as Distance measure, ‘Row and column means are removed’ was selected for Standardization method, and ‘Symmetrical’ was selected as Normalization method.

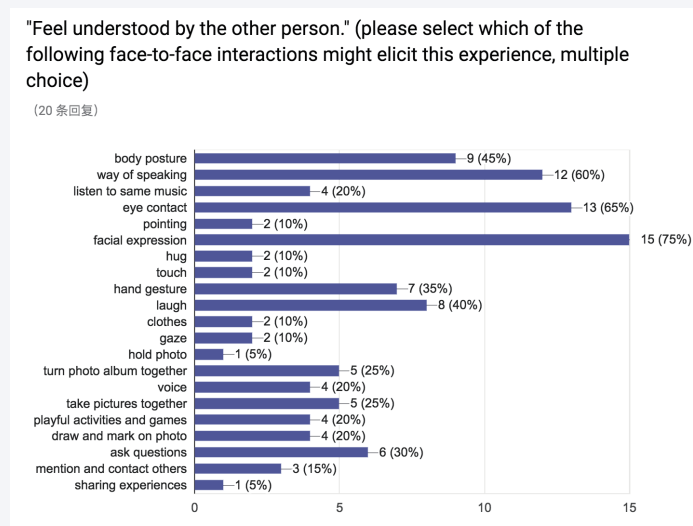


Fig 16 An example of the online survey results (if the participant believe the interaction can elicit the experience, one vote was given)

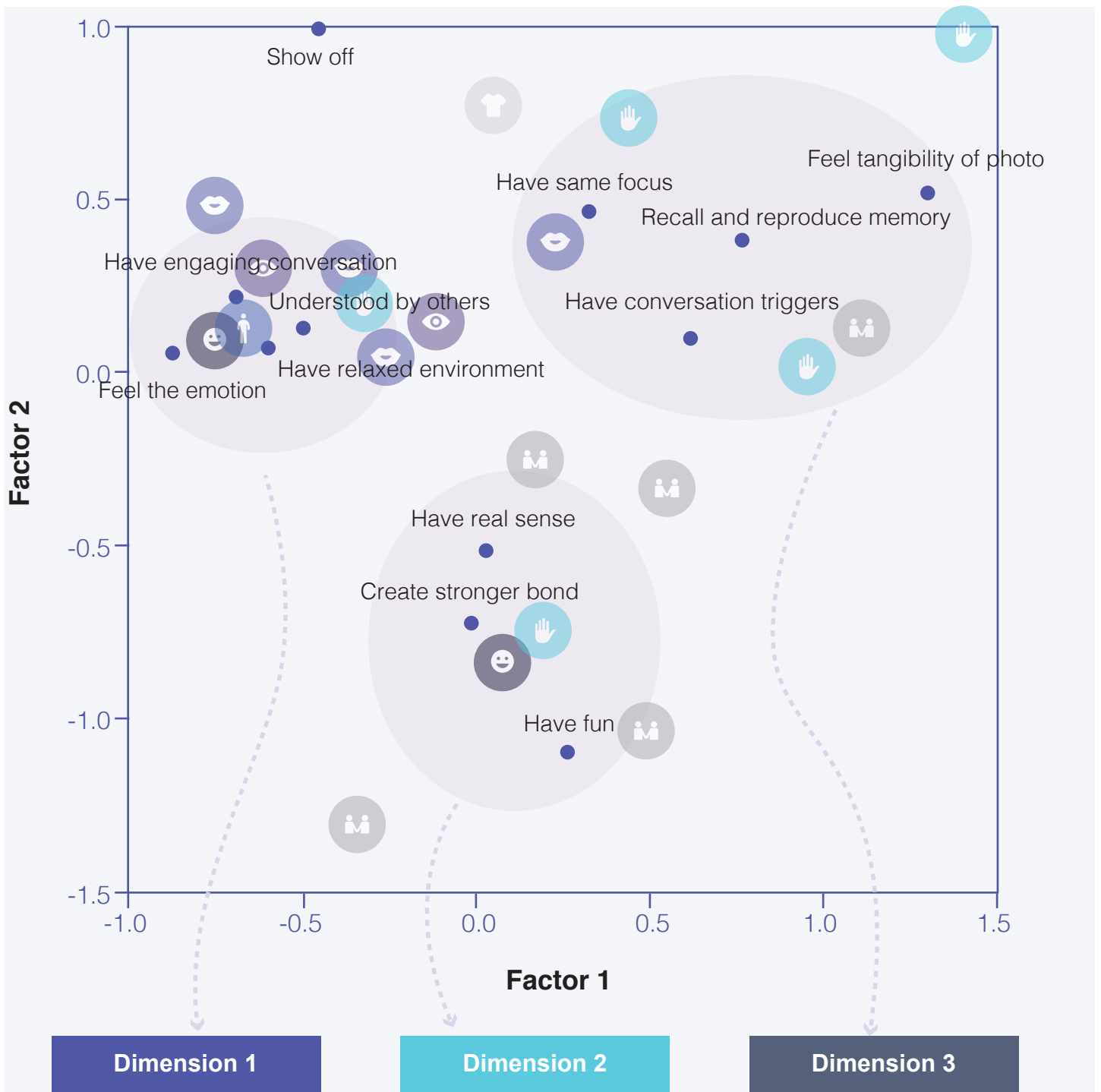


Fig 17 The visualized Biplot (all the categories of experience and groups of interactions were clustered along two factors)

Results

The scatterplots: Row-points plot, Column-points plot and Biplot were produced. Since the Biplot is a combination of Row Points plot and Column Points plot, we will only use the Biplot for further analysis (the other plots can be found in Appendix 5). A visualized Biplot is shown in Fig 17.

Three groups can be identified, according to how different elements are distributed in the Biplot. Except for the category 'show off', the other 11 categories of experience are all included in one of the three dimensions of experience. In the following pages, the components for each dimension will be discussed.

Dimension 1

Components of experience



QUALITY OF EXPERIENCE

Fig 18 The categories of experience included in dimension 1

Dimension 1 - Quality of interaction

Four categories of experience were included in this dimension of experience: 1) understood by others; 2) engaging conversation; 3) feel the emotion; 4) relaxed environment. Except for the last one, the other three are all about how people communicate and interact with each other. Therefore we define this dimension of experience as 'Quality of interaction'.

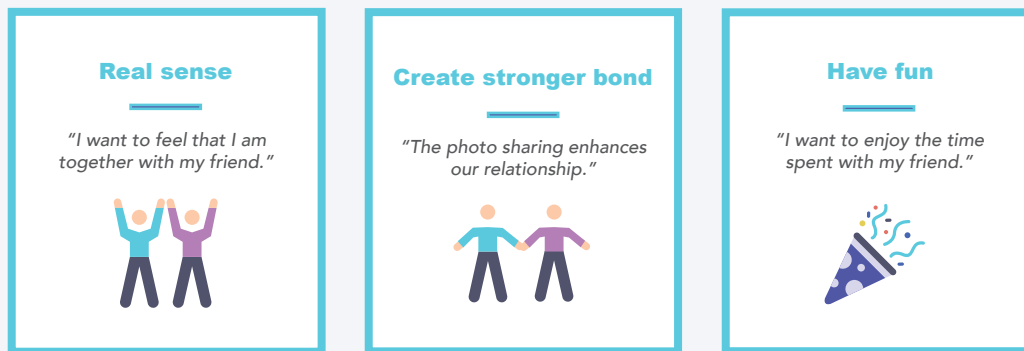
In the field of virtual reality, 'quality of interaction' is often described as the ability of the user to move within the virtual world and to interact with the objects in the virtual world [10, 31]. When multiple users are considered, quality of interaction is defined as the experience of interacting with the system and with others via the system [8]. This is an important dimension of experience since it informs about how well interactions between people are supported.

Some of the important issues addressed with 'quality of interaction' are: 1) Can people communicate well with each other and can they understanding each other? 2) Can people get

engaged in the conversation? 3) Can they feel each other's emotion? 4) If the environment around the conversation is relaxed? These questions should be considered when evaluating the 'quality of interaction'.

Dimension 2

Components of experience



SOCIAL MEANING

Fig 19 The categories of experience included in dimension 2

Dimension 2 - Social meaning

Three categories of experience were included in this dimension of experience: 1) Real sense; 2) Create stronger bond; 3) Have fun. The first category is about the feeling of being physically together. The other two are about feeling socially connected. Therefore, we define this dimension of experience as 'social meaning'.

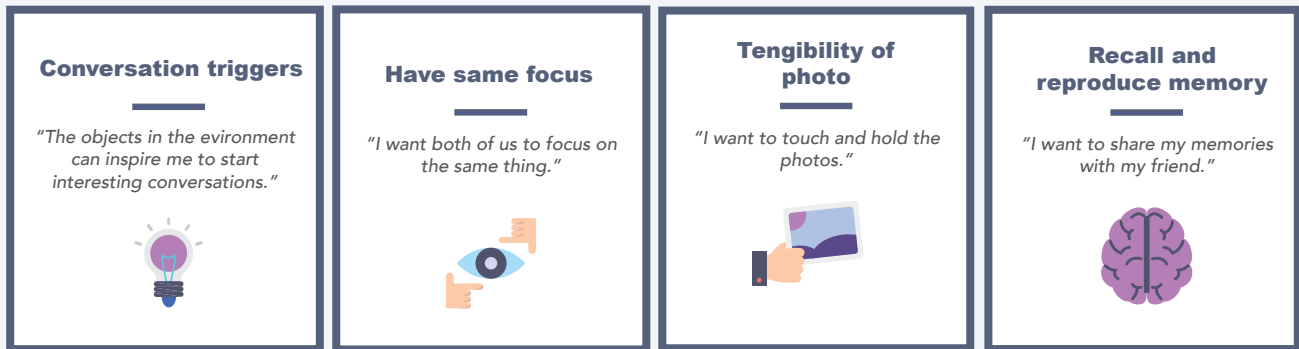
The social meanings for using mediated communication tools refers to the experience of belongingness and connectedness to other people, which is also a central concept in understanding and evaluating communication media, such as social VR [18]. Two aspects of connectedness are often studied in this field. One is about mental connectedness, the 'social connectedness'. And the other is about physical connectedness, the 'togetherness'. These two aspects can cover the categories of experience in this dimension. Detailed explanation can be found in PART 3.

When designing evaluation methodologies for 'social meaning', we need to consider: 1) if people can actually feel physically together

with their partner? 2) If people feel the closeness of their relationship is improved after the activity? 3) Do people enjoy the social interaction?

Dimension 3

Components of experience



PRESENCE & IMMERSION

Fig 20 The categories of experience included in dimension 2

Dimension 3 - Presence and immersion

Four categories of experience were included in this dimension of experience: 1) Conversation triggers; 2) Have same focus; 3) Tengibility of photo; 4) Recall and reproduce memory. Apart from the last one, the other three categories are all about feeling in the environment and staying focused. Therefore this dimension was defined as 'Presence and immersion'. After discussion, the last category was moved to the second dimension: social meaning.

This dimension of experience mainly results from design elements of forms and settings. These design elements affect perception and the immediate, intuitive understanding of what is going on within a social setting. Presence and immersion are two of the most important perception.

When evaluating presence and immerison, the following questions need to be addressed: 1) If people feel they are actually in the environment? 2) If they are focused on what they are doing? 3) If they feel the environment

surrounding them are immersive enough?

Conclusions and Insights

In this part, an interaction-centered methodology was used to explore the user experience during photo sharing. First a list of different categories of experience was gathered through context mapping. These categories were further clustered according to their relationships with different types of interactions. Finally three dimensions of experience were identified: 1) quality of interaction; 2) social meaning; 3) presence and immersion. These dimensions of experience match with the frameworks developed in the field of mediated social communication and virtual reality, as mentioned in PART 1.

However, the limitation of these findings is that it only applies to the specific scenario of photo sharing. In order to make it more commonly applicable, each dimension of experience is verified with literature research in PART 3. The definitions for each dimensions of experience are defined, and related evaluation methodologies are reviewed.

1. Please indicate, on the chart below, your own emotion and the emotion of your partner during the VR photo sharing.

5. I often felt my partner and I in the same space.

14. I think my partner often felt alone during photo sharing.

13. I often felt as if I was all alone during photo sharing.

close attention to my partner.

My partner was easily distracted when things were going on around us.

2. I was able to feel my partner's emotion during the photo sharing experience in VR.

was sure that my partner often felt my emotion.

19. Through the VR photo sharing experience, I was able to share my memories with my partner.

20. I derived little satisfaction from photo sharing with my partner.

4. It was easy for me to contribute to the conversation.

21. The photo sharing experience with my partner felt superficial.

27. My VR photo sharing felt as if it was a face-to-face conversation.

25. Somehow I felt that the conversation was not natural, as if I was not really there.

5. The conversation seemed highly interactive.

6. I could readily tell when my partner was listening to me.

26. I had a hard time interacting in the virtual space, as if I was not really there.

29. I felt detached from the outside world during the VR photo sharing.

acting in the virtual space, as if I was not really there.

22. I really enjoyed the time spent with my partner during the VR photo sharing experience.

difficult to keep track of the conversation.

8. I felt completely absorbed in the conversation.

9. I could fully understand what my partner was talking about.

10. I was very sure that my partner understood what I was talking about.

the time, I was not really there.

31. My thoughts and feelings were very much on my mind.

12. The actions used to interact with my partner were similar to the ones in the real world.

g seemed

32. It felt like the VR photo sharing took a shorter time than it really did.

11. The experience felt natural.

PART 3 DESIGNING AN EVALUATION METHODOLOGY

An evaluation methodology is developed according to the research findings in PART 2. This methodology consists of a quantitative part and a qualitative part. For the quantitative part, a questionnaire is developed, based on a set of questions selected from related work. For the qualitative part, a semi-structured interview is designed.

3.1 INTRODUCTION



3.2 LITERATURE REVIEW



- Measuring user experience in social VR
- Questionnaires
- Other evaluation methods

3.3 DESIGN OF THE METHODOLOGY



- Quantitative part
- Qualitative part

3.1 INTRODUCTION

In PART 2, three dimensions of experience were identified. In this part, each of these three dimensions is explored based on a literature review.

First, the definitions for each dimension of experience are proposed. After that, existing evaluation methodologies are explored.

Relevant methodologies are selected and combined into a new methodology. This new evaluation methodology is tested in a pilot experiment with 10 participants. Based on the test results, adjustments and improvements are made. The improved version is used in a formal user experience evaluation experiment in PART 4.

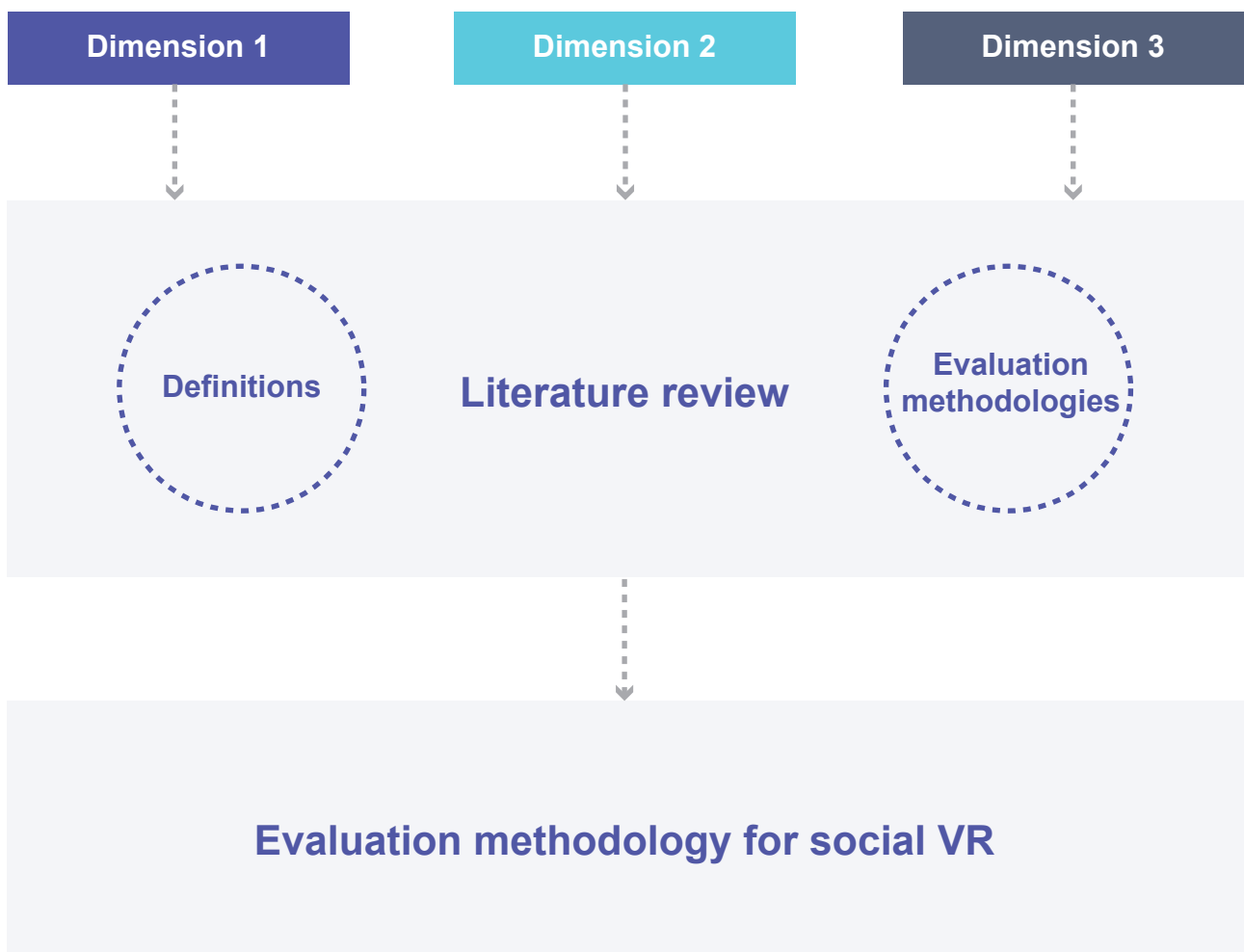


Fig 21 The process of evaluation methodology design

3.2 LITERATURE REVIEW

Measuring user experience in social VR

The measurability of UX has always been complicated. Although UX is generally believed to be a cognitive process that can be modeled and measured [3], the design of meaningful data collection methods is very difficult.

As UX is subjective [24], objective usability measures such as task execution time and the number of clicks or errors are not sufficient. In order to find out how users feel, questionnaires are often used. As a commonly used tool for the user-driven assessment of software quality and usability, questionnaires allow efficient quantitative measurements of product features, and sophisticated assessments of the strengths and weaknesses of interactive products [7]. With reference to a recent survey, 53% of the user experience studies have employed questionnaires to yield quantifiable results ([4], [5]).

In the field of social VR, researches studying the user experience often adopt mixed methods, both quantitatively and qualitatively. Questionnaires are frequently used to get the quantitative responses of the 'subjects'. Other methods such as interviews and observations are often used to get qualitative responses.

Questionnaires

User experience evaluation of social VR is still an emerging research topic, so there are no standard questionnaires for UX evaluation. Researchers need to develop their own questionnaires, based on existing questionnaires from related fields, such as mediated social communication and virtual reality. Therefore, for each dimensions of experience found in PART 2, related questionnaires used in other research studies will be collected, compared and discussed.

Dimension 1 - Quality of interaction

Quality of interaction in virtual reality is often described as the ability of the user to move

within the virtual world and to interact with the objects in the virtual world [10, 31]. When multiple users are considered, quality of interaction is defined as the experience of interacting with the system and with others via the system [8]. This is an important category of experience since it informs about how well social VR can support interactions between people. For quality of interaction, three categories of experience are often evaluated: 1) quality of communication; 2) experienced emotion; 3) naturalness of interaction.

- Quality of communication

Garau et al. investigated the impact of visual and behavioral realism in avatars on perceived quality of communication with post-experiment questionnaires. The questionnaire was developed based on previous research of Sellen [30]. The quality of communication was measured in four dimensions: 1) how natural the conversation seemed; 2) degree of involvement in the conversation; 3) sense of co-presence and 4) satisfaction with the conversation partner [11].

Steen et al. also emphasized on the importance of quality of communication in mediated social interaction, but they provided some different dimensions: 1) Understanding and being understood; 2) being able to communicate one's intentions and having the feeling the others can do the same; 3) knowing how the other is feeling during the social interaction and having the feeling the other knowing your feelings as well [22]. Compared with the questionnaire from Garau et al., which emphasizes more on the communication process, the questionnaire from Steen et al. focuses more on the result and influence.

Most of these questionnaires were developed based on the previous research findings in the field of mediated social communication. One of the most frequently referred questionnaires was the one developed by Sellen [30].

- Experienced emotion

The emotions that people experience during mediated social interactions are important. Some of the relevant issues are whether people have a positive or negative experience, to what degree, with which intensity, and if they feel overwhelmed or in control. These issues are able to influence the overall user experience [8]. The abstract nature of emotional responses makes it especially challenging to quantify them. Nonetheless, attempts have been taken to measure emotion ([12], [14]).

A range of evaluation metrics for emotion has been developed. For example, PMRI is a rich and easy-to-use pictorial mood-reporting instrument developed by Vastenburg et al. [12].

The study of Riva et al., analyzed the possibility of using VR as an affective medium. He used three questionnaires to evaluate the emotion of VR users: Visual Analogue Scale, Positive and Negative Affect Schedule and State Trait Anxiety Inventory. The research result confirmed that VR is an affective medium [13]. Although the experience of emotion is recognized an important part of mediated social experience, subjective metrics are not often applied [35].

- Naturalness of interaction

When interacting with virtual environments, naturalness refers to how a system connects human actions with corresponding changes in the mediated environment [15]. This measurement is often used to assess how well virtual tools can support real world interaction, which is an essentially part of social VR user experience. Nilsson et al. measured the perceived naturalness of leg movements in virtual reality with four factors: 1) Naturalness; 2) Physical strain; 3) self-motion compellingness and 4) Acclimatization [16].

Some researches defined naturalness of interaction as a factor of presence, instead of quality of interaction. For example, in the presence

questionnaire developed by Witmer et al., three questions were about naturalness [22].

Dimension 2 - Social meaning

The social meaning for using mediated communication tools refers to the experience of belongingness and connectedness to other people, which is also a central concept in understanding and evaluating communication media, such as social VR [18]. Two aspects of connectedness were often studied in this field. One is about mental connectedness, the 'social connectedness'. And the other is about physical connectedness, the 'togetherness'.

- Social connectedness

According to Vanbel et al. social connectedness is a short-term experience of belongingness and relatedness, based on quantitative and qualitative social appraisals, and relationship salience [18]. They developed a 29 items questionnaire for social connectedness at the individual level (regarding a particular person) and 36 items for social connectedness at the overall level (whole social network). Several factors were identified for social connectedness: 1) relationship salience; 2) satisfaction with contact quality; 3) shared understandings; 4) knowing each other's experiences and 5) feelings of closeness.

Social connectedness is also evaluated in psychological studies as a measure for belongingness [17]. These studies serve as references for developing questionnaires for mediated social interaction.

- Togetherness

Apart from mental connectedness, there is also a physical aspect of connectedness – togetherness. Durlach et al. defined togetherness as the sense of people being together in a shared space [19].

Togetherness in virtual environments sometimes can also be understood as social pres-

ence or co-presence. It was Short et al. who introduced and defined the term social presence as 'the salience of the other in a mediated communication and the consequent salience of their interpersonal interactions.' The level of social presence is the extent to which a medium is perceived as sociable, warm, sensitive, personal, or intimate when it is used to interact with other people [25]. Based on these understandings, Sallnas developed a questionnaire with 13 questions for social presence/togetherness/co-presence [27].

However, social presence is not always the same as togetherness or co-presence. Biocca et al. based on the factor analysis of social presence, created a factor structure with three underlying dimensions: co-presence, psychological involvement and behavioral involvement [20]. The psychological involvement includes empathy and mutual understanding, which is, as discussed previously, part of social connectedness. The behavioral engagement, which includes behavioral interdependence, mutual assistance and dependent action, can be part of the quality of interaction. These findings put co-presence/togetherness as a factor of social presence. Social presence in this case became a broader experience category.

Dimension 3 - Presence and immersion

Presence and immersion are the keys to distinguish virtual reality among other mediated communication tools.

- Presence

Presence was defined by Witmer and Singer as 'the subjective experience of being in one place or environment, even when one is physically situated in another' [22]. The most widely used questionnaire for presence was also designed by them. The contributing factors for presence identified in the questionnaires were: 1) control factors, 2) sensory factors, 3) distraction factors and 4) realism factors.

The factors for presence varied in different

questionnaires. In the study of Schubert et al., a presence questionnaire was developed based on other three factors: spatial presence, involvement and realness [28].

- Immersion

Immersion is a psychological state characterized by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences [22]. Factors that affect immersion include 1) isolation from the physical environment; 2) perception of self-inclusion in the virtual environment and 3) natural modes of interaction, and control and perception of self-movement.

According to Jennett et al. immersion for gaming can be measured based on 1) lack of awareness of time; 2) loss of awareness of the real world and 3) involvement and a sense of being in the task environment [29].

The experiences of presence, immersion and involvement have complex relationship. Overlap can be found in the questionnaires of presence and immersion. Involvement and the degree of immersion are believed to affect the sense of presence [22]. The virtual world that produces greater sense of immersion increases the level of presence. Finally, a high level of immersion increases the level of involvement.

Other evaluation methods

In order to have a comprehensive understanding of user experience, questionnaires are always used together with other qualitative methods, such as interviews and observations. The reason that more and more researchers are adopting these methods is that qualitative and quantitative data can be simultaneously collected, analyzed and interpreted [59].

- Interviews

One of the common methods used in mixed methodology design is the interview. Burns et al. contended that interview is a popular and

widely used method for collecting qualitative data. Researchers cannot observe the feelings and thinking. Interview is a key to understand what and how people perceive and interpret the world around them [60].

Qualitative interviews have been categorized in a variety of ways, with many contemporary texts loosely differentiating qualitative interviews as unstructured, semi-structured and structured [64]. Semi-structured in-depth interviews are the most widely used interview format for qualitative research. They are generally organized around a set of pre-determined and open-ended questions, with additional questions emerging from the dialogue between the interviewer and interviewee [65].

- Observations

Observation is a preplanned research tool which is carried out purposefully to answer research questions [59]. Observation enables the researcher to combine it with questionnaires and interviews to collect relatively objective firsthand information [61]. In the field of virtual reality, observation is often used to collect objective behavioral data. In the research of Smith et al., participants' behaviors were tracked with different technologies used to analysis communication quality [23]. In the study of Second Life conducted by Yee et al., observation data from avatar is used in order to explore whether social norms of gender, interpersonal distance and eye gaze are the same with real world behavior [66]. In order to get the precise behavioral data, certain data collecting technologies need to be developed.

3.3 DESIGN OF THE METHODOLOGY

Quantitative part

- Selection of questions

For each dimensions of experience discussed in the literature review, a definition is selected. Question items from existing questionnaires are selected as references based on two criteria: 1) If the definition of experience matches with our definition; 2) If the field of research is close to social VR. An overview of the definitions and the questionnaire references is given below.

- Dimension 1 - Quality of interaction

The ability of the user to interact with the virtual world and/or to interact with others in the virtual world ([8], [10], [31]).

Quality of communication

The questionnaire developed by Garau et al. [11] for social VR, and the one developed by Steen et al [8] for mediated social communication are used as references.

Experienced emotion

The tool PMRI developed by Vastenburg et al. [12] for mood-reporting is used.

Naturalness of interaction

The questionnaire developed by Nilsson et al. [16] for virtual reality is used as reference.

- Dimension 2 - Social meaning

The experience of mental and physical connectedness to other people [18].

Social connectedness

The questionnaire developed by Vanbel et al. [18] for mediated social communication is used as reference.

Togetherness

The questionnaire developed by Biocca et al. [20] for social VR is used as reference.

- Dimension 3 - Presence and immersion

The subjective experience of being in one place or environment, and the psychological state of perceiving oneself to be enveloped by, included in, and interacting with an environment [22].

Presence

The questionnaire developed by Schubert et al. [28] for virtual reality is used as reference.

Immersion

The questionnaire developed by Jennett et al. [29] for VR is used as reference.

Based on these references and our previous user research findings in PART2, a first version of the questionnaire was designed, which can be found in Appendix 6. This version was tested in a pilot experiment with 10 colleagues from Centrum Wiskunde & Informatica. Based on the pilot test, some confusing items were removed. The final version of questionnaire (used in the experiment in PART 4) can be found in Fig 23, Fig 24 and Fig 25. The questions are asked with a 5-level likert scale.



Fig 22 The pilot experiment to test the first version of evaluation methodology

Qualitative part

The semi-structured interview, as explained by Zohrabi [59], are selected to complement the questionnaire. Four predetermined open-ended questions were designed. The first three questions were designed according to the three dimensions of experience. I want to find out what do users think of these dimensions of

experience and identify the major factors influencing these dimensions of experience. The last one is an open question about the future of social media. I want to know what are people's expectations of social media and how can social VR be better positioned as a social tool.

1. Compared with face-to-face condition, what do you think is missing in Skype or FB Social VR, in terms of interaction?

How well do you sense the emotion of your partner?

What do you think of the quality of communication?

How do they influence your experience? What problem do they bring?

Is there any special interaction you like about Skype or FB Social VR?

2. How do you feel about photo sharing experience?

Do you think it help you maintain your relationships?

Will you use it for getting along with your friends? Which condition will you use? Why?

Apart from photo sharing, what else do you want to do with your partner in Skype or Social VR?

3. Are you satisfied with the virtual environment?

Do you feel comfortable inside the virtual world?

Do you think you are actually in the virtual world? Do you think it is immersive enough?

4. How do you think the product can be improved in the future?

What types of people do you want to meet? What kind of relationships do you want to develop?

What do you think is the next generation of social media?

Questionnaire for Facebook Space

Please answer the questions, according to your experience about photo sharing in social VR.

1. Please indicate, on the chart below, your own emotion and the emotion of your partner during the VR photo sharing. Please also indicate the emotion intensity (0-100). You only need to report the emotion you have experienced.

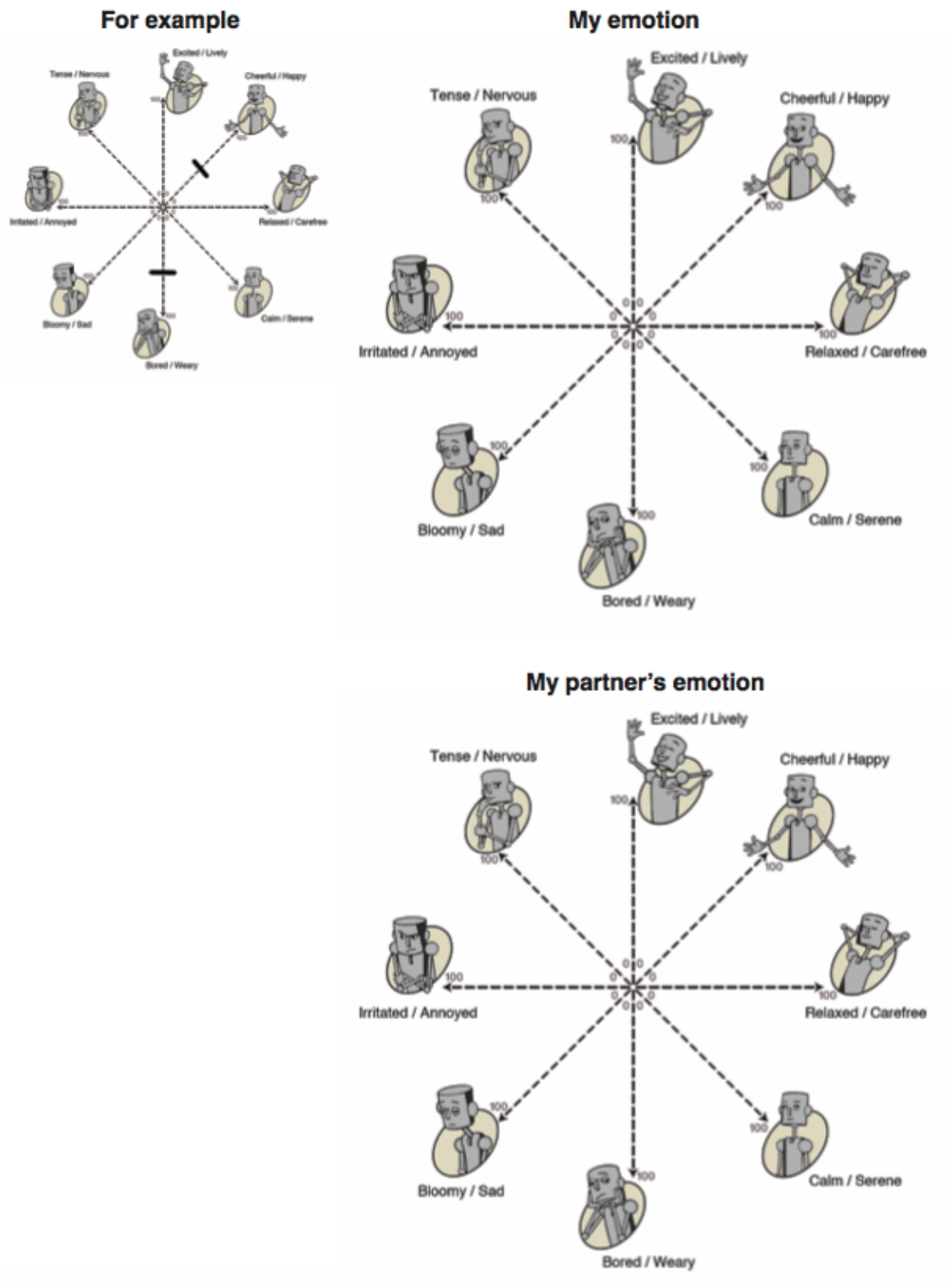


Fig 23 Part 1 of the final questionnaire

The scale of the following questions are from 1 to 5, representing the following meanings:
1 Strongly disagree **2 Disagree** **3 Neutral** **4 Agree** **5 Strongly agree**

Strongly disagree	1	2	3	4	5	Strongly agree
	1	2	3	4	5	
2. "I was able to feel my partner's emotion during the VR photo sharing."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. "I was sure that my partner often felt my emotion."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. "It was easy for me to contribute to the conversation."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. "The conversation seemed highly interactive."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. "I could readily tell when my partner was listening to me."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. "I found it difficult to keep track of the conversation."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. "I felt completely absorbed in the conversation."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. "I could fully understand what my partner was talking about."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. "I was sure that my partner understood what I was talking about."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11. "The experience of photo sharing seemed natural."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12. "The actions used to interact with my partner were similar to the ones in the real world."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	1	2	3	4	5	
Strongly disagree	1	2	3	4	5	Strongly agree
13. "I often felt as if I was all alone during the VR photo sharing."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
14. "I think my partner often felt alone during the VR photo sharing."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
15. "I often felt my partner and I were sitting together in the same space."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
16. "I paid close attention to my partner."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
17. "My partner was easily distracted when other things were going on around us."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
18. "I felt that the photo sharing experience in VR enhanced our closeness."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
19. "Through the VR photo sharing, I managed to share my memories with my partner."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20. "I derived little satisfaction from photo sharing with my partner."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
21. "The photo sharing experience with my partner felt superficial."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
22. "I really enjoyed the time spent with my partner."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Fig 24 Part 2 of the final questionnaire

See graph below	1	2	3	4	5	6	7
23. How emotionally close to your partner do you feel now?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5	6	7	

Strongly disagree	1	2	3	4	5	Strongly agree	1	2	3	4	5
24. "In the virtual world, I had a sense of 'being there'."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
25. "Somehow I felt that the virtual world was surrounding me and my partner."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
26. "I had a sense of acting in the virtual space, rather than operating something from outside."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
27. "My VR photo sharing experience seemed as if it was a face-to-face sharing."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
28. "I did not notice what was happening around me in the real world."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
29. "I felt detached from the outside world during the VR photo sharing."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
30. "At the time, I was focusing totally on the photo sharing."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
31. "Everyday thoughts and concerns were still very much on my mind."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
32. "It felt like the VR photo sharing took shorter time than it really was."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
33. "When sharing the photos time appeared to go by very slowly."	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Thank you for your feedback!

Fig 25 Part 3 of the final questionnaire



PART 4 EVALUATING USER EXPERIENCE IN AN EXPERIMENT

In this part, the evaluation methodology developed in PART 3 is used in a user experience experiment. We compare the experience of photo sharing in Social VR with Face-to-face situation and Skype situation. Pairs of participants who know each other joined the experiment. The results show that social VR provides good experience of 'social meaning' and 'presence & immersion'.

4.1 INTRODUCTION



4.2 EXPERIMENT DESIGN



- Research questions
- Methods
- Participants
- Setup
- Data collection
- Procedure

4.3 RESULTS



- Questionnaire results
- Interview results

4.4 CONCLUSIONS



4.1 INTRODUCTION

In this part, the methodology defined in PART 3 will be used to evaluate user experience in social VR. In order to do that, a user experience experiment is designed. Three conditions are selected: Face-to-face, Skype and Facebook Space. Participants are asked to share photos with their partners in these three different conditions. Their experience is evaluated based on questionnaires and interviews.

The results of the experiment help us to identify the advantages and disadvantages of social VR in terms of user experience. These findings contribute to the creation of design recommendations in PART 5.

Why three conditions?

In order to find out the advantages and disadvantages of social VR as a mediated social communication tool, three conditions are selected, shown in Fig 26. The Face-to-face condition is selected because it serves as a standard condition, according to the literature discussed in PART 1. The Skype condition is selected because it is one of the traditional mediated social communication tools, and the way people interact in Skype is close to real life.

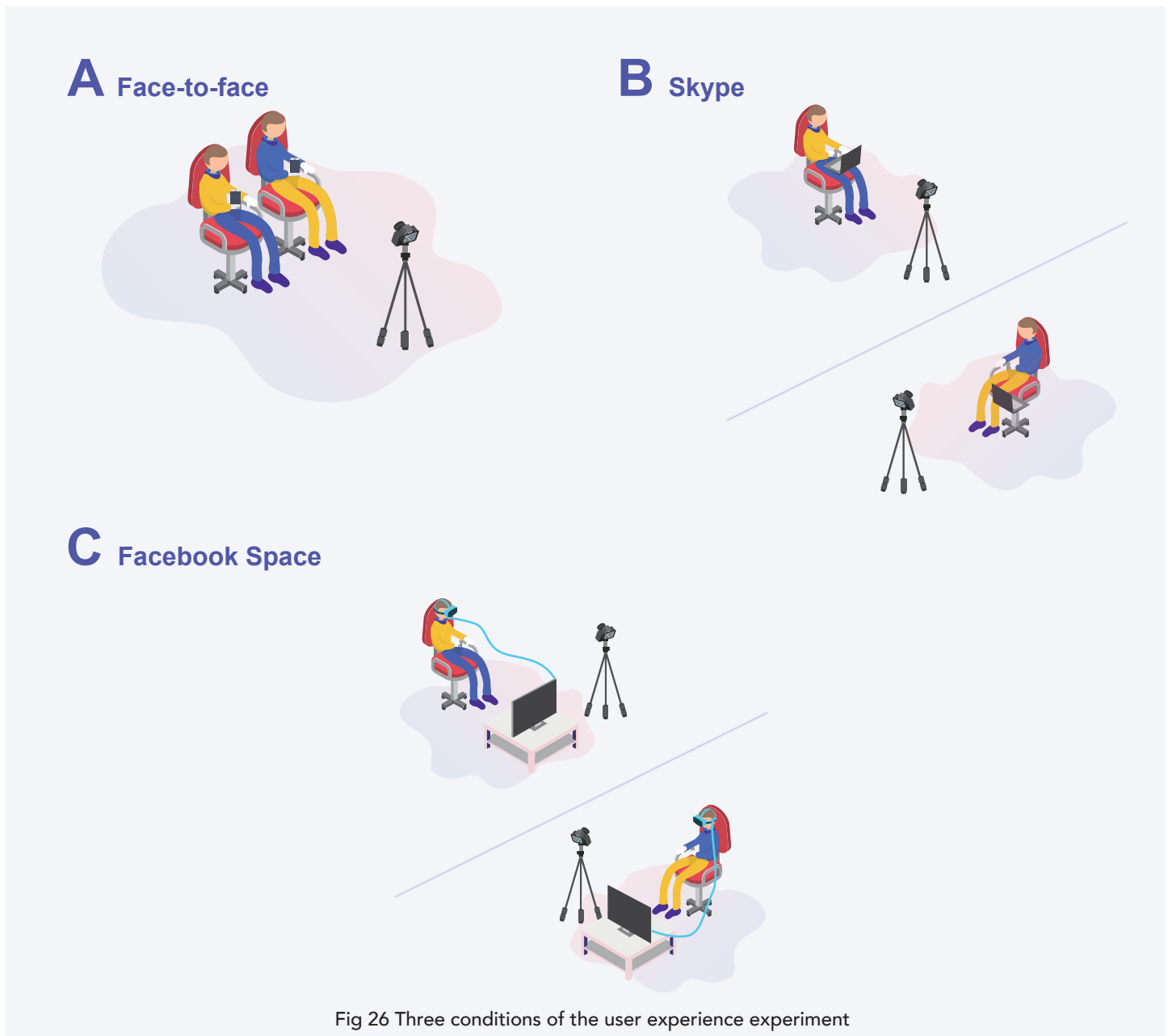


Fig 26 Three conditions of the user experience experiment

4.2 EXPERIMENT DESIGN

Research questions

“Compared with Face-to-face condition, how is the user experience of digital photo sharing in social VR and Skype.”

“What are the advantages and disadvantages of social VR?”

Methods

This experiment applies a within-subjects research method, as is applied in the research of Smith et al. [23]. This method helps us to better compare the three conditions. Each pair of subjects is asked to share photos with each other in three conditions:

A Face-to-face condition

Two participants sit together and use their mobile phones to share photos with each other. Each participant will share one photo.

B Skype condition

Two participants sit in different rooms, and each person will see the other person through Skype in a laptop. They still share photos with each other using mobile phones. Each participant will share one photo, but a different one.

C Facebook-space condition

Two participants sit in different rooms. Each person uploads one photo into Facebook Space, and they enter a virtual room together to share one photo with each other. The photo should be different from the other two.

After each condition, participants answer a questionnaire about the experience in the condition. After all conditions are completed, interview is conducted. The sequence of different conditions is randomized according to Latin square. The whole process is video recorded.

Participants

According to literature, approximately 24 users for within-subjects experiments are needed. In

this experiment, we work with 26 pairs of users.

Users are selected based on the following criteria:

- Two people who know each other well (additional requirements: they have photo sharing experiences in the past)
- Willing to provide 3 photos to be shared in the experiment.
- Novice users of social VR.
- Have no visual problems/ known problems with 3D videos or using VR hardware.

Totally 29 males and 23 females are recruited.

Setup

Due to space and complexity constraints, the experiment is setup in a big room by splitting the space into two separate ‘rooms’ using a physical divider.

The setup of the experiment is decided according to the context mapping results in PART 2. Both rooms have a similar layout consisting of a pair of chairs, placed side by side. (Shown in Fig 27) Each room also has its own computer, which is able to run Oculus Rift.

For Face-to-face (A): participants sit in two comfortable chairs side by side.

For Skype call (B): participants sit in comfortable chairs in two rooms. Their bodies are displayed on computer screens and placed in front of their partner.

For Facebook social VR (C): participants sit in comfortable chairs in two rooms. Their virtual bodies are placed together in the virtual environment side by side, a floating table appears in front of them. (The background of the virtual environment is a 360-degree shooting of the experiment room.)



A Face-to-face



B Skype



C Facebook Space

Procedure

The detailed procedure can be found in Fig 28. The whole process takes around one hour, and is video recorded. All the questionnaires and forms can be found in Appendix 7.

Data collection

Quantitative data

The users are asked to: answer the questionnaire shown in PART 3, at the end of each condition.

Qualitative data

An interview is performed at the end of each experiment. Participants were asked to answer several open-ended questions, shown in PART 3. The interviews were voiced recorded and transcribed after the experiments.

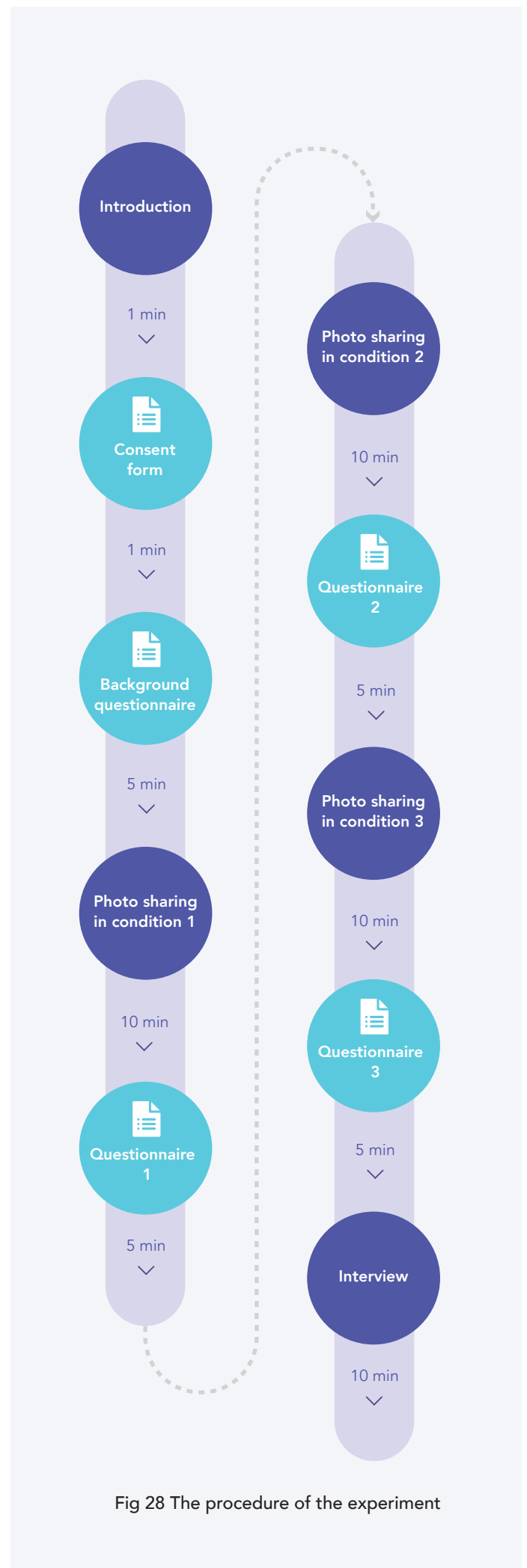


Fig 28 The procedure of the experiment

4.3 RESULTS

Questionnaire results

The direction of scoring on reverse-worded items was reversed first. Exploratory factor analysis (EFA) [67] was performed. The specific method Principle Component Analysis was applied. Three components were identified and Reliability analysis was performed for each of the factors. Subsequently, the sensitivity and validity of these factors were explored using additional background variables collected with the 'Background questionnaire'.

- Principle Component Analysis

Since some presence and immersion items are missing in the Face-to-face questionnaire, only the results from the Skype questionnaire and Facebook Space questionnaire were used for the PCA analysis. The analysis was conducted on the 33 items with oblique rotation (direct oblimin). The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis, $KMO=0.851$ (great according to Field [68]). Bartlett's test of sphericity ($496 = 2176.797$, $p < 0.001$), indicated that correlations between items were sufficiently large for PCA. An initial analysis was run to obtain eigenvalues for each component in the data. Three components were selected, explaining 51.92% of the total variance. Although a few more eigenvalues were higher than one, the scree plot showed a clear bend after the third component, which justified the selection of the three components.

Table 1 shows the factor loadings after rotation. The three components generally match with our previous defined three dimensions of experience, except that some question items were moved from one dimension to another. The three components were therefore named: 1) Presence and immersion; 2) Quality of interaction; 3) Social meaning.

Presence and immersion

The first component that emerged was called 'Presence and immersion'. Nine out of the

twelve items loading on this component were selected for the scale. The item ("The conversation seemed highly interactive.") was deleted because it loads 0.405 on component 1 and 0.357 on component 2. The two items about 'naturalness' were also removed since they loaded on two components. Finally, the scale consists of the following items. The scale is very reliable, Cronbach's alpha = 0.925, the factor loadings range from 0.923 to 0.436.

18. "I felt that the photo sharing experience in VR enhanced our closeness."

15. "I often felt my partner and I were sitting together in the same space."

24. "In the virtual world, I had a sense of 'being there'."

25. "Somehow I felt that the virtual world was surrounding me and my partner."

26. "I had a sense of acting in the virtual space, rather than operating something from outside."

27. "My VR photo sharing experience seemed as if it was a face-to-face sharing."

28. "I did not notice what was happening around me in the real world."

29. "I felt detached from the outside world during the VR photo sharing."

30. "At the time, I was focusing totally on the photo sharing."

Quality of interaction

The second component was named as Quality of interaction. Eight items loading on this component, as are shown below, were all selected for the scale, which has Cronbach's alpha = 0.860, and the factor loadings between 0.799 and 0.416.

2. "I was able to feel my partner's emotion during the VR photo sharing."

3. "I was sure that my partner often felt my emotion."

4. "It was easy for me to contribute to the conversation."

6. "I could readily tell when my partner was listening to me."

9. "I could fully understand what my partner was talking about."

10. "I was sure that my partner understood what I was talking about."

16. "I paid close attention to my partner."

19. "Through the VR photo sharing, I managed to share my memories with my partner."

Social meaning

The third component was named as Social meaning. Six out of seven items loading on this component were all selected for the scale. The last item ("I found it difficult to keep track of the conversation") was deleted since it loads equally on two components. For this scale, Cronbach's alpha = 0.806, and the factor loadings between 0.702 and 0.542.

13. "I often felt as if I was all alone during the VR photo sharing."

14. "I think my partner often felt alone during the VR photo sharing."

20. "I derived little satisfaction from photo sharing with my partner."

21. "The photo sharing experience with my partner felt superficial."

31. "Everyday thoughts and concerns were still very much on my mind."

33. "When sharing the photos time appeared to go by very slowly."

The following two items were moved from presence and immersion to social meaning. These two items are literally all about whether people enjoy the photo sharing or not, which can be part of social meaning.

31. "Everyday thoughts and concerns were still very much on my mind."

33. "When sharing the photos time appeared to go by very slowly."

Other output data of PCA can be found in Appendix 8.

Item movements

The changes made to the original questionnaire are shown in Fig 29. Apart from the deletion of some problematic items, there were some movements of items between different dimensions.

The following two items were moved from social meaning to presence and immersion, which indicated that the feeling of togetherness relates with presence and immersion.

15. "I often felt my partner and I were sitting together in the same space."

18. "I felt that the photo sharing experience in VR enhanced our closeness."

The following two items were moved from social meaning to quality of interaction. The item 16 is about mutual attention, which can also be part of quality of interaction. Item 19 is actually influenced by the quality of communication. Therefore it makes sense when moved to quality of interaction.

16. "I paid close attention to my partner."

19. "Through the VR photo sharing, I managed to share my memories with my partner."

Table 1 Pattern Matrix of Principle component analysis

	Component		
	1	2	3
In the virtual world, I had a sense of 'being there'.	.923		
Somehow I felt that the virtual world was surrounding me and my partner.	.899		
I had a sense of acting in the virtual space, rather than operating something from outside.	.893		
I often felt my partner and I were sitting together in the same space.	.833		
My VR photo sharing experience seemed as if it was a face-to-face sharing.	.808		
I felt detached from the outside world during the VR photo sharing.	.783		
I did not notice what was happening around me in the real world.	.610		
The experience of photo sharing seemed natural.	.537	.450	
I felt that the photo sharing experience in VR enhanced our closeness.	.499		
At the time, I was focusing totally on the photo sharing.	.436		
The actions used to interact with my partner were similar to the ones in the real world.	.418		
The conversation seemed highly interactive.	.405		
I felt completely absorbed in the conversation.			
I was sure that my partner understood what I was talking about.		.799	
I could fully understand what my partner was talking about.		.776	
I was sure that my partner often felt my emotion.		.754	
I was able to feel my partner's emotion during the VR photo sharing		.693	
I could readily tell when my partner was listening to me.		.689	
I paid close attention to my partner.		.479	
Through the VR photo sharing, I managed to share my memories with my partner.		.432	
It was easy for me to contribute to the conversation.		.416	
My partner was easily distracted when other things were going on around us.			
How emotionally close to your partner do you feel?			
Everyday thoughts and concerns were still very much on my mind.			.702
When sharing the photos time appeared to go by very slowly.			.665
I derived little satisfaction from photo sharing with my partner.			.591
I often felt as if I was all alone during the VR photo sharing.			.588
I think my partner often felt alone during the VR photo sharing.			.583
The photo sharing experience with my partner felt superficial.			.542
I found it difficult to keep track of the conversation.		.425	.444
I really enjoyed the time spent with my partner.			
It felt like the VR photo sharing took shorter time than it really was.			

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

a. Rotation converged in 12 iterations.

Table 2 Component correlation Matrix

Component	1	2	3
1	1.000	.300	.337
2	.300	1.000	.322
3	.337	.322	1.000

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

QUALITY OF EXPERIENCE

2. "I was able to feel my partner's emotion during the VR photo sharing."

3. "I was sure that my partner often felt my emotion."

4. "It was easy for me to contribute to the conversation."

~~5. "The conversation seemed highly interactive."~~

6. "I could readily tell when my partner was listening to me."

~~7. "I found it difficult to keep track of the conversation."~~

~~8. "I felt completely absorbed in the conversation."~~

9. "I could fully understand what my partner was talking about."

10. "I was sure that my partner understood what I was talking about."

~~11. "The experience of photo sharing seemed natural."~~

~~12. "The actions used to interact with my partner were similar to the ones in the real world."~~

SOCIAL MEANING

13. "I often felt as if I was all alone during the VR photo sharing."

14. "I think my partner often felt alone during the VR photo sharing."

15. "I often felt my partner and I were sitting together in the same space."

16. "I paid close attention to my partner."

~~17. "My partner was easily distracted when other things were going on around us."~~

18. "I felt that the photo sharing experience in VR enhanced our closeness."

19. "Through the VR photo sharing, I managed to share my memories with my partner."

20. "I derived little satisfaction from photo sharing with my partner."

21. "The photo sharing experience with my partner felt superficial."

~~22. "I really enjoyed the time spent with my partner."~~

~~23. How emotionally close to your partner do you feel now?~~

PRESENCE & IMMERSION

24. "In the virtual world, I had a sense of 'being there'."

25. "Somehow I felt that the virtual world was surrounding me and my partner."

26. "I had a sense of acting in the virtual space, rather than operating something from outside."

27. "My VR photo sharing experience seemed as if it was a face-to-face sharing."

28. "I did not notice what was happening around me in the real world."

29. "I felt detached from the outside world during the VR photo sharing."

30. "At the time, I was focusing totally on the photo sharing."

31. "Everyday thoughts and concerns were still very much on my mind."

~~32. "It felt like the VR photo sharing took shorter time than it really was."~~

33. "When sharing the photos time appeared to go by very slowly."

Fig 29 The changes to the questionnaire according to principle component analysis

- Sensitivity and validity

Based on the item division above, we compared the scores of these three dimensions of experience in different situations: with different technology, different genders and length of relationships.

- Different technologies

For each of the three conditions, their average 'quality of interaction' scores were calculated. Significant different mean scores were found between these conditions with ANOVA test ($F(2,151)=13.900$, $p<0.001$). Face-to-face condition ($M=4.299$, $SD=0.744$) was scored significantly higher quality of interaction than other two conditions: Skype ($M=3.588$, $SD=0.640$) and Facebook Space ($M=3.875$, $SD=0.644$). There was no significant different between Skype and Facebook space condition.

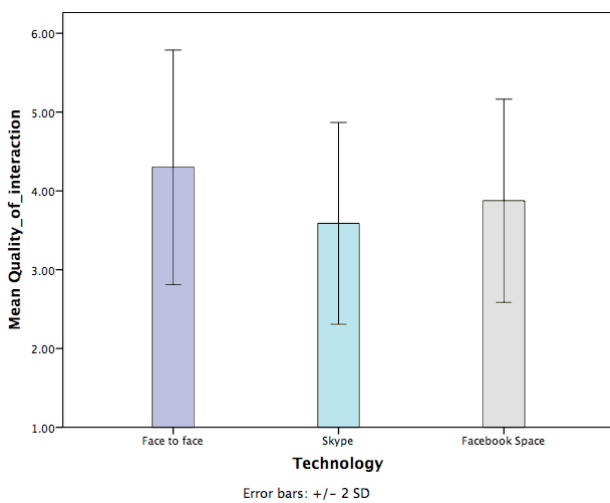


Fig 30 The score of quality of interaction in three conditions, score values range from 1 to 5 (SD indicated in graph)

For the three conditions, their average social meaning score were also calculated. Significant different mean scores were found between these conditions with ANOVA test ($F(2,154)=8.337$, $p<0.001$). Both Face-to-face condition ($M=3.878$, $SD=0.806$) and Facebook Space condition ($M=3.974$, $SD=0.713$) were scored significantly higher than Skype condition ($M=3.412$, $SD=0.718$). And no significant difference between Face-to-face condition and Facebook Space condition was found.

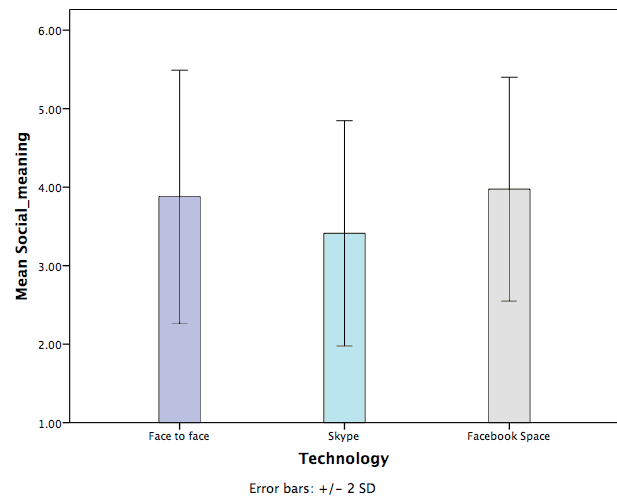


Fig 31 The score of social meaning in three conditions, score values range from 1 to 5 (SD indicated in graph)

For presence and immersion, Face-to-face condition was given default highest score. Significant difference was found between the presence and immersion levels ($F(2,153)=280.339$, $p<0.001$). The Face-to-face condition ($M=5$, $SD=0$) was scored significantly higher than other two conditions: Facebook Space condition ($M=3.987$, $SD=0.668$) and Skype condition ($M=2.485$, $SD=0.671$). Facebook Space condition was also significantly higher than Skype condition.

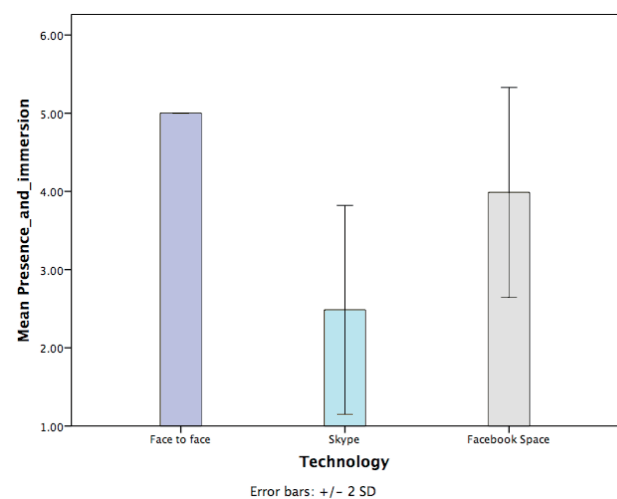


Fig 32 Mean score of presence & immersion in three conditions, score values range from 1 to 5 (SD indicated in graph)

In Fig 33 and Table 3, the mean scores for all the dimensions were put together to compare.

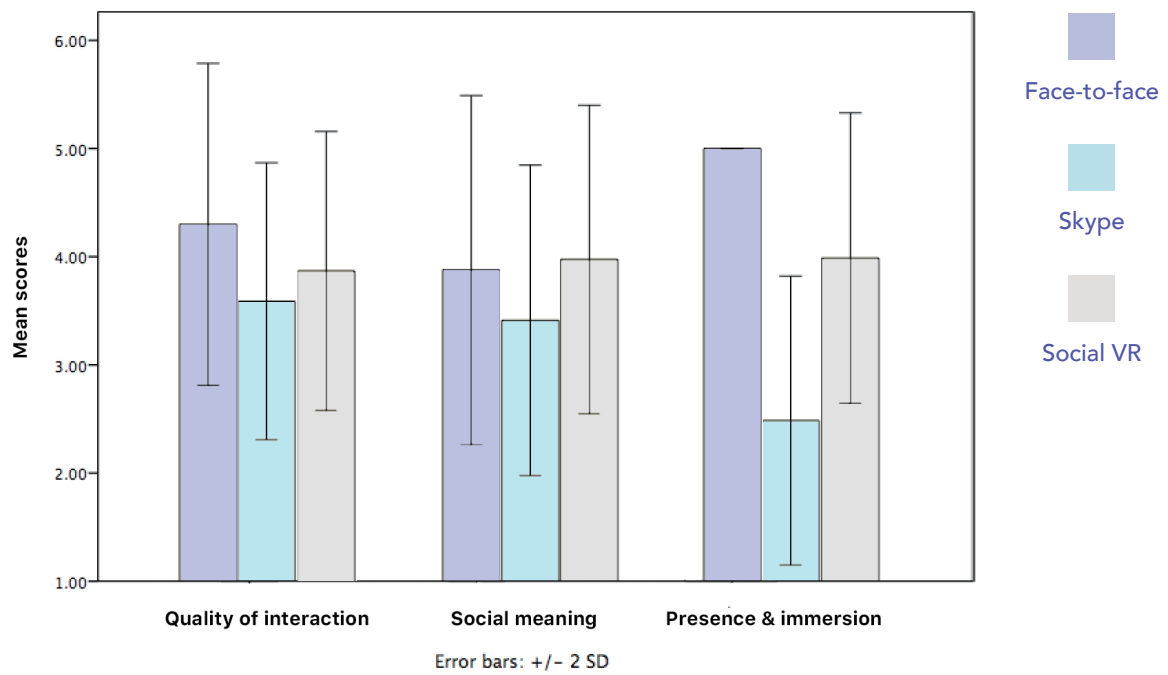


Fig 33 The mean scores of three dimensions for three conditions, score values range from 1 to 5 (SD indicated in graph)

Table 3 The mean scores of three dimensions of experience in three conditions

	Quality of interaction	Social meaning	Presence & immersion
Face-to-face	4.299	3.878	5.000
Skype	3.588	3.412	2.485
Social VR	3.875	3.974	3.987

- Different genders

Apart from different technology conditions, the influence of gender factor on different dimensions of experience was also explored. Participants reported their genders in the Background questionnaire. The pairs were divided into three groups: male-male, female-female and male-female. Two-way ANOVA was performed. Homen variances = 0.016, the error variance of the dependent variable is not equal across groups. Only the technology factor has significant influence on the quality of interaction level ($F=10.229$, $p<0.001$). Gender factor no significant influence on the quality of interaction, neither did the interaction factor of gender and technology. For the other two dimensions of experience, 'social meaning' and 'presence and immersion', the findings were the same. Therefore, the gender factors do not influence different dimensions of experience.

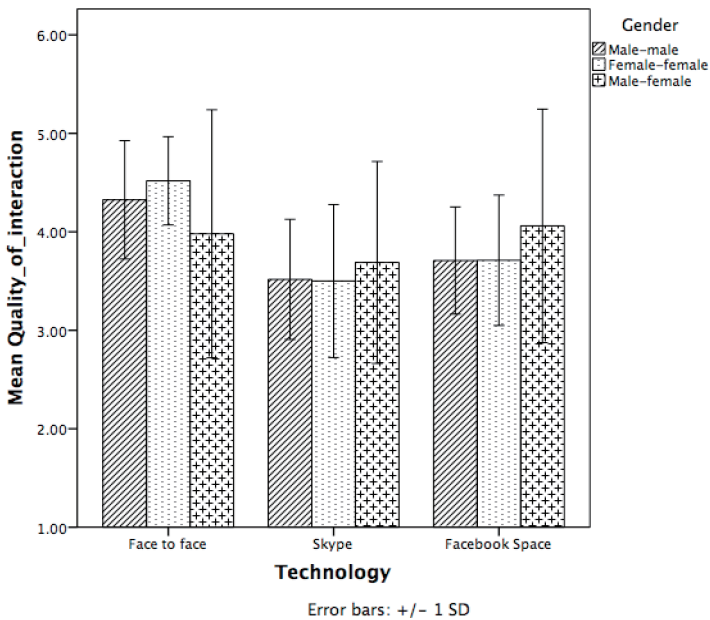


Fig 34 The influence of gender factor on quality of interaction, score values range from 1 to 5 (SD indicated in graph)

- Different length of relationships

The factor 'Length of relationship' was also explored with the three dimensions of experience. There are three levels of relationships: 1) knowing each other less than one year; 2) knowing each other between 1 and 3 years; 3) knowing each other more than 5 years. (Another level 4-5 years was not selected by any participants) With two-way ANOVA, significant influences of length of relationship factor ($F=5.496$, $p=0.005$) on 'social meaning' were found. Participants knowing each other more than 5 years scored 'social meaning' significantly lower than participants who know each other less than 1 year or 1~3 years. This indicates that people knowing each other for a long time have higher requirements for 'social meaning'.

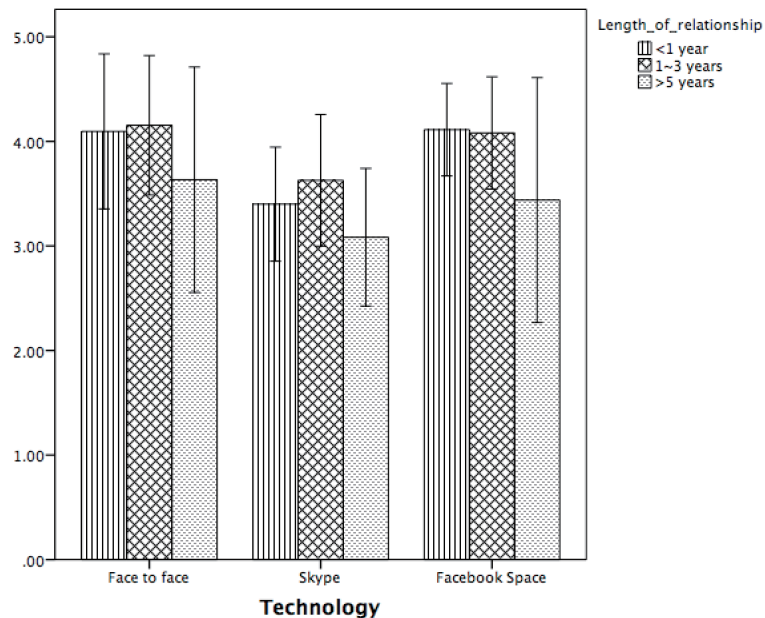


Fig 35 The influence of length of relationship on social meaning, score values range from 1 to 5 (SD indicated in graph)

- Reported emotion analysis

For each condition, participants reported their own emotions during the photo sharing, and they also reported their partner's emotion according to their interpretations. The emotion was reported on a diagram with 8 types of emotions: 4 positive emotions and 4 negative emotions. The scores for each emotion was measured and calculated. For each condition, the mean of participants' own emotion and their partners' emotion were calculated and plotted together in a diagram. The mean scores between their own emotions and partner's emotion were compared.

Face-to-face

As shown in Fig 36, the 'tense and nervous' participants experienced themselves ($M=7.14$, $SE=2.17$) are significantly higher than what they think their partner did ($M=3.09$, $SE=1.07$), $t(51)=-2.040$, $p<0.047$, $r=0.412$. For all the other emotions, no significant differences were found, indicating that participants felt their partner had similar emotions with themselves.

Skype

As shown in Fig 37, the 'tense and nervous' participants experienced themselves ($M=16.48$, $SE=3.51$) are significantly higher than what they think their partner did ($M=8.38$, $SE=2.83$), $t(51)=-2.384$, $p=0.021$, $r=0.441$. For all the other emotions, no significant differences were found.

Facebook space

As shown in Fig 38, the 'calm and serene' Participants experienced themselves ($M=14.22$, $SE=3.60$) are significantly lower than what they think their partner did ($M=22.87$, $SE=4.76$), $t(51)=-2.078$, $p<0.043$, $r=0.533$. For all the other emotions, no significant differences were found.

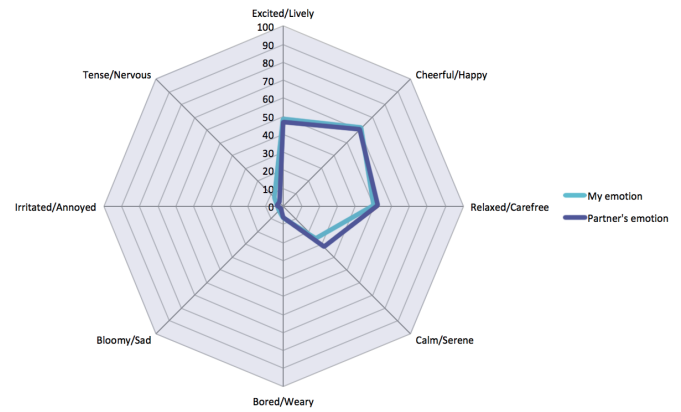


Fig 36 The emotion reported in the face-to-face condition, score values range from 1 to 100

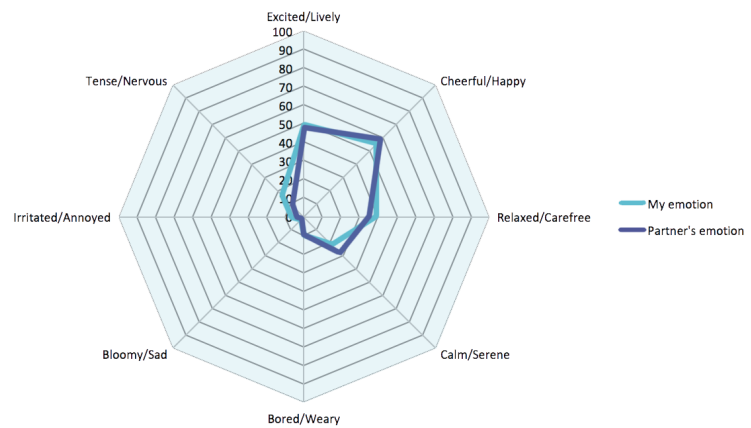


Fig 37 The emotion reported in the Skype condition, score values range from 1 to 100

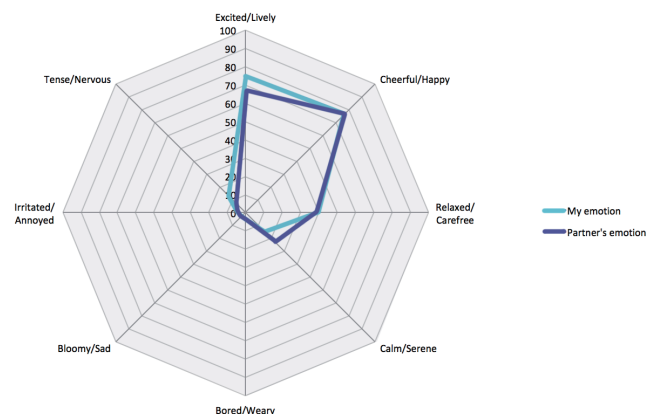


Fig 38 The emotion reported in Facebook Space condition, score values range from 1 to 100

Comparing Fig 36, Fig 37 and Fig 38, we can see that in all three conditions, the emotion of participants and their partners generally matches with each other, and there are not a lot of differences.

Another interesting finding is that participants generally felt they are more tense and nervous compared with their partners. At the same time, they also felt their partners are more calm and relaxed than themselves. The tense feeling could be caused by the experiment settings, or the pressure to say something interesting. And this feeling was not expressed to the partners.

All three conditions

Participants' own emotions in three conditions were put together in one graph to compare (shown in Fig 39).

Overall, people experienced more positive emotions than negative emotions. Especially in Facebook space, people felt more excited and cheerful than the other two situations. Later in the interview part, the reason was explained: this was due to the 'wow factor' of the novel interactions in the social VR.

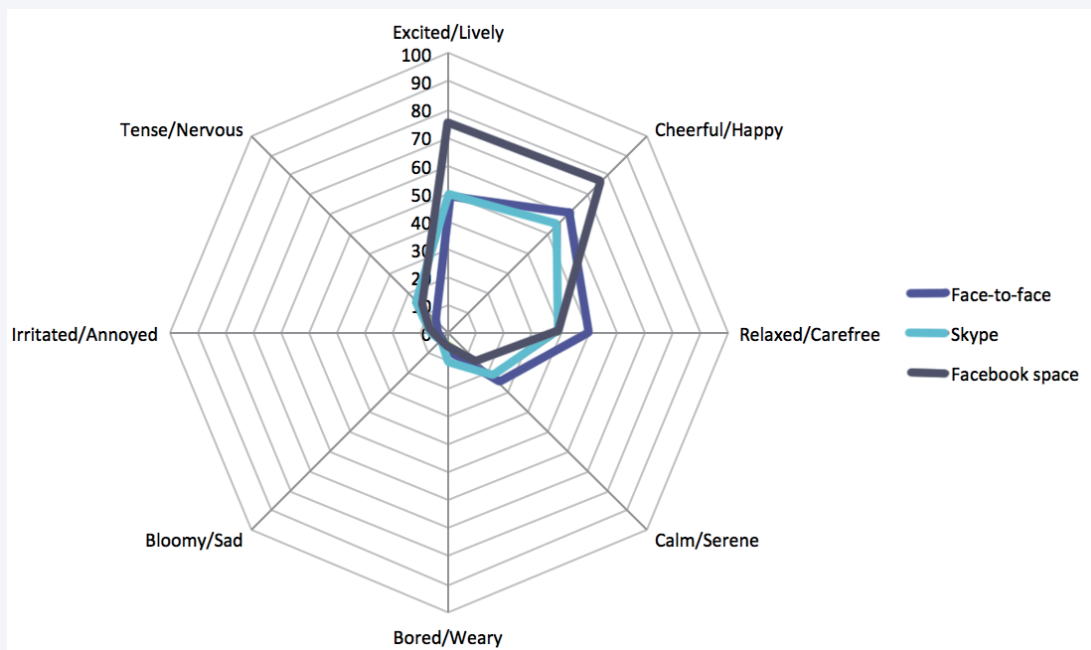


Fig 39 Participants' own emotions for the three conditions, score values range from 1 to 100

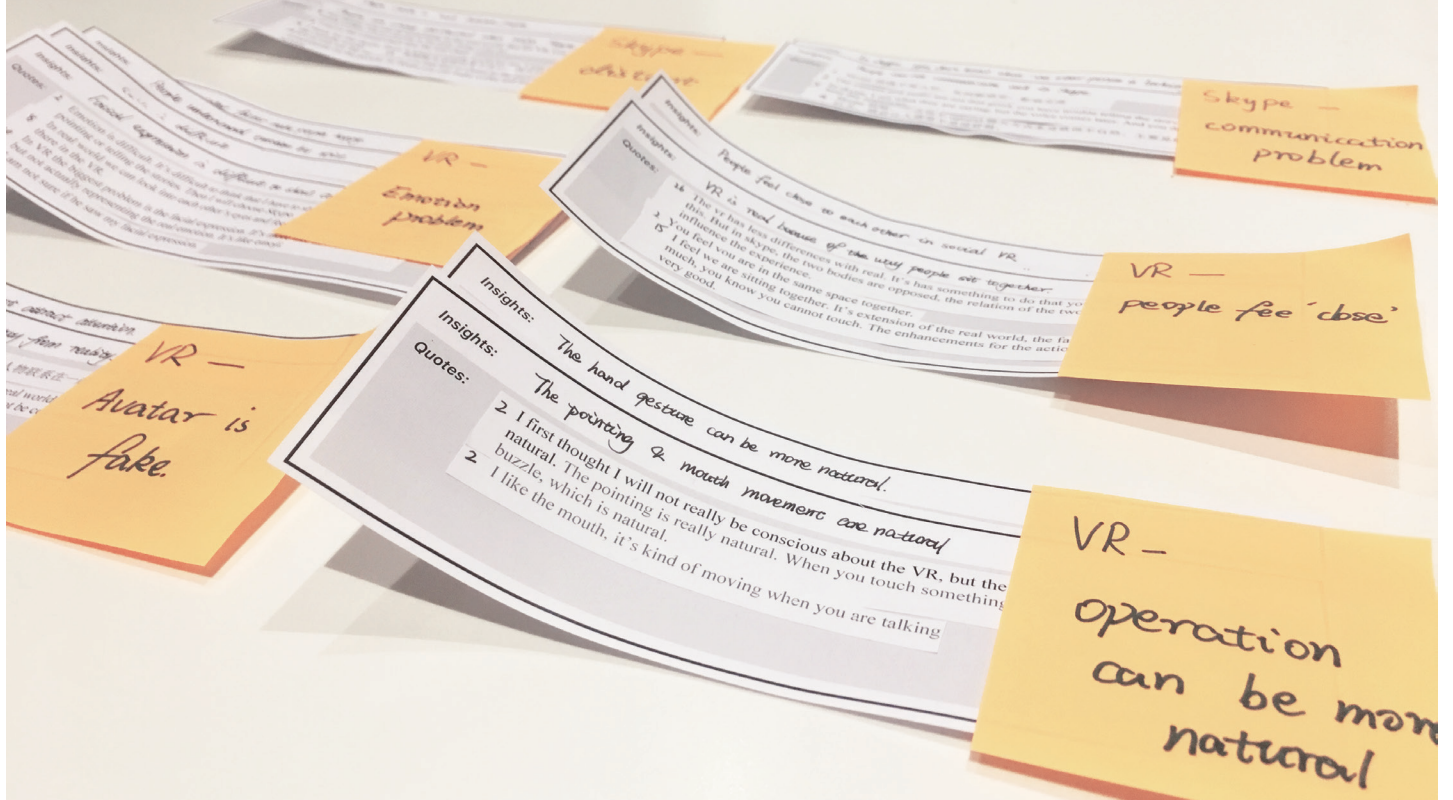
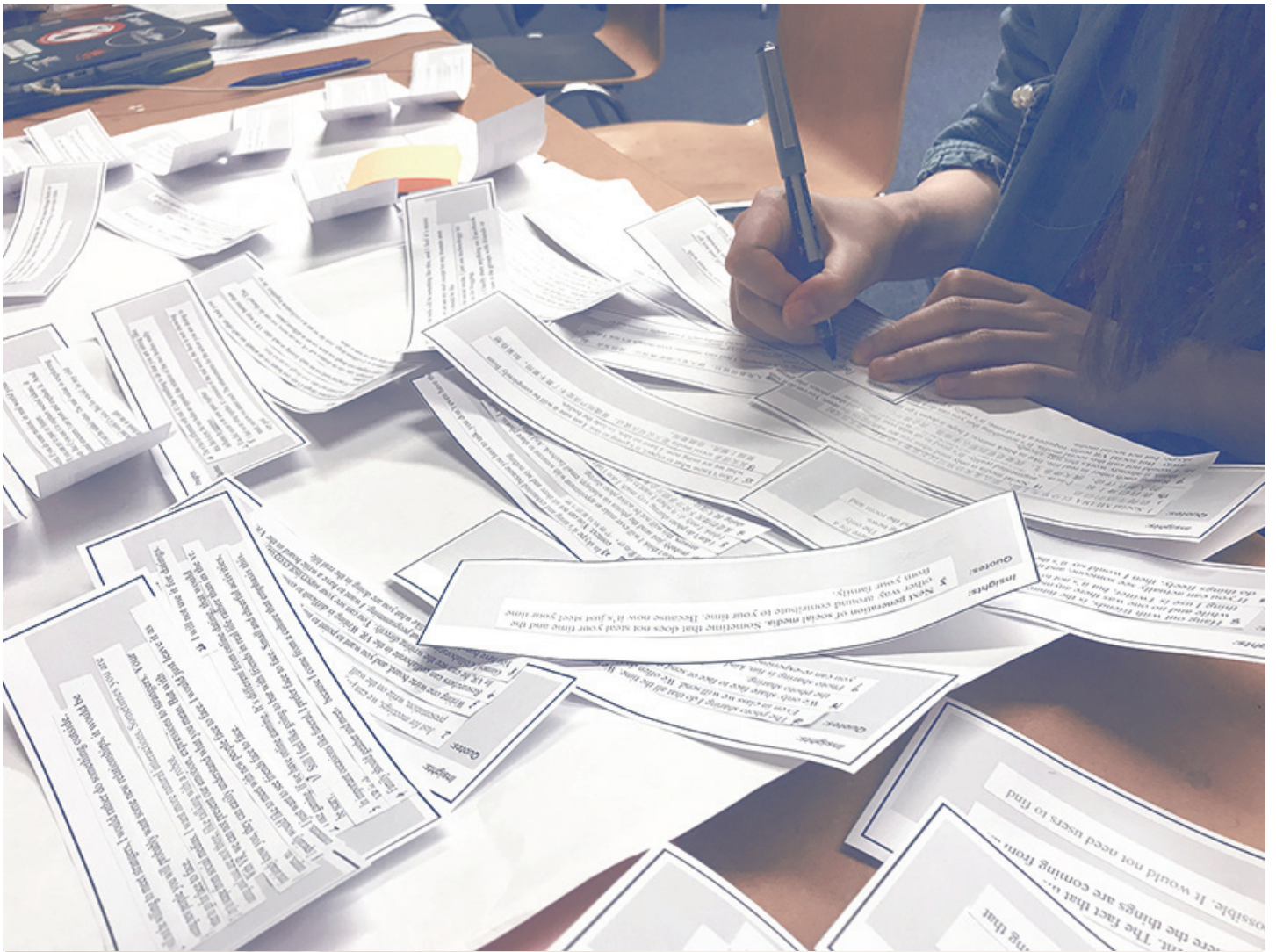


Fig 40 Analyzing the interview results

Interview results

The interviews with 26 pairs of participants were transcribed (detailed transcripts can be found in Appendix 9). For each of the questions, interesting answers were selected and interpreted. The selected contents were further clustered into meaningful patterns.

Q1 Compared with face-to-face condition, what do you think is different in Skype or FB Social VR, in terms of interaction?

Q1.1 What's missing?

Q1.2 What do you like?

In the questionnaire analysis part, it was found that the quality of interaction of Skype and Facebook Space were significantly lower than Face-to-face situation. In this part of the interview, the detailed reasons were explained.

For Skype

There are two main drawbacks found with Skype interaction. Firstly, **Skype makes people feel distant with each other**. That's because the way it displays the other person makes people feel that they are at two different places. Another reason is that **people feel distracted by the environment** when using Skype, which make the partner feel that they are not focused on the conversation.

"Skype is kind of curtain between you two." - 23

The other drawback of Skype is that **there are problems with information communication**. Firstly, people don't know where the other person is looking at. Secondly, the delay of voice information makes people confused.

"In Skype, I see what they are saying, but the voice comes later. And you don't clearly hear the sentences" - 5

For Facebook Space

For Facebook Space, the first problem with interaction is that **the avatar is far away from reality**, and people don't feel they actually see each other. Also, the avatars do not catch enough attention from the users since it's too cartoonish and people are easy to neglect it.

"You are still in the VR thing, it's still different from the real world. In VR you don't actually see each other." - 1

Another big problem with VR is the expressing of emotions. **The way people show emotion is not natural** and people have to think about what they need to show. The selection of facial expression was also too limited and people feel constrained. Due to this reason, people tend to judge the other person's emotion by voice, and they do not pay attention to the avatar. People also mentioned that they feel very excited and happy due to the wow factors in the new technology, and this feeling might disappear after using it for some period.

"Emotion is difficult. It's difficult to think that I have to show emotion, when I am pointing or telling the stories." - 2

The naturalness of interaction can be improved. People mentioned that the pointing was natural since it's similar with real world gestures. However, **some other hand gestures take time for people to learn** how to use them. The naturalness of interaction was identified as part of Presence and Immersion, however, people still mentioned as part of quality of interaction. It remains to be discussed to which dimension of experience naturalness belongs.

"The gestures are not really communicative." – 9

Apart from the drawbacks mentioned above, there are also some advantages. What people do like about VR is that **it makes people feel close, compared with Skype condition.** People explained that the way that they sit together contribute to the feeling of closeness. The settings in VR make people focus on each other.

"Feels like we are in a civilization together." - 5

Q2 How do you feel about photo sharing experience?

Q2.1 How do you feel about photo sharing activity?

Q2.2 What else do you want to do in the social VR?

People said sharing photos helps to enhance friendship. However, **the context of photo sharing is very important**, while in the social VR the context is missing. People feel awkward to just stay together and share photos.

"It's tiring and exhausted because you have to talk, you don't even have the context." – 23

Different relationships require different types of activities. People want more intimate activities with close relationships. With strangers, game was considered as a good choice.

"Depends on what's your goal, for long distance relationships, hug girl friend. Otherwise, doing something together like board games." - 12

People mentioned that the **VR can bring new forms of social interactions.** They can feel part of friends' life in different ways. A lot of promising functions were mentioned by participants: the most frequently mentioned was gaming, followed by exploring the world, collaborating in 3D space, training, family gatherings. People also mentioned that **the strength of social VR lies in the none-realistic social activities, not everyday socials.** This can be observed in the experiment that people are generally more interested in the 3D spaces and what they can do rather than the photo sharing.

"Maybe some kind of novel interactive approaches to feel part of friends' lives." – 12

Q3 Are you satisfied with the virtual environment?

People didn't have a lot of comments for this question. People already feel very immersed with VR since there's no 'frame' and the environment was 360. Compared with Skype, people feel far more immersive and present. This was also identified in the questionnaire analysis. However, they think the presence could be improved by using high quality images and by reducing the weight of the head

mounted display. Currently the heavy HMD always reminded them that they are in the VR. This part of experience is more dependent on the technology development.

"I don't saw any boarder, so I feel very immersive." - 3

Q4 What do you think is the future of social media?

Q4.1 What types of people do you want to meet in social VR?

Q4.2 What do you think is the next generation of social media?

Platforms for meeting strangers and close friends should be separated. For meeting strangers, people consider more about the safety and privacy issues. While for friends or families, they want some intimate interactions. The social context actually influence the types of people they want to meet

"If you meet strangers, you can control more. But it's too risky, you can not delete what you don't want." - 6

People believe face-to-face interaction cannot be replaced. For some specially occasions like dating and family gathering, face-to-face can not be replaced. People still believe face-to-face social is the real social, and they are afraid that social media makes people less social. Currently, a lot of 2D online platform occupies the time of users while not providing the real sense of social. They even feel more distant with families around them since they waste too much time online. Therefore, a lot of people are trying to get away from social

media. People expect the new generation of social media to **provide meaningful interactions with friends and families and add value for their social interactions.** These findings justify the importance 'social meaning' in the evaluation of social medias. And since social VR was scored very high for social meaning, it can be a promising social tool.

"I feel people are disconnected on the social medias. I would like to feel more connected to families and friends." - 16

Regarding the trend of social media, people generally feel not in control. Some people think it will be more decentralized, while others think it will be more open and light-weighted. People feel it's going too fast, and the trend is controlled by big companies. They complain that the social medias are not transparent enough. A lot of hidden mechanisms are using their data to do something else. **The future social medias should give more controls back to it users.**

4.4 CONCLUSIONS

The evaluation methodology

According to the results from the experiment, the evaluation methodology works well. The three dimensions of experience were verified by the Principle Component Analysis. The general composition of the questionnaire is good, although some small changes are needed according to the PCA. The semi-structured interview revealed a lot of valuable insights from the participants, which helped to explain the reason behind the quantitative results. More reflections can be found in PART 6.

User experience of social VR

With the evaluation methodology, I was able to find the advantages and disadvantages of social VR.

The biggest advantage of social VR is that it provides good sense of presence and immersion. Current social medias such as Skype cannot match with it. This is also the main reason why people use social VR. It is suggested that designers social VR should make good use of this advantage to create novel experiences.

The social meaning is also found to be a potential advantage for social VR, according to the experiment results. People enjoy spending time together in the social VR and they feel close with each other when inside the virtual space. However, some issues need to be taken into consideration: 1) the social context needs to be considered; 2) the right social value need to be delivered.

In terms of quality of interaction, there is much space for improvements. The operation system can be more smart and intuitive to use. The appearance of avatar also requires big improvements.

PART 5 PROVIDING DESIGN RECOMMENDATIONS

The experiment results in PART 4 help us to understand the current user experience of social VR, and how it can be improved to create better experience. Based on the findings, design recommendations for future social VR design are proposed in this part.

5.1 DESIGN FOR SOCIAL MEANING



5.2 DESIGN FOR QUALITY OF INTERACTION



5.3 DESIGN FOR PRESENCE AND IMMERSION



5.2 Designing for social meaning

Select the types of relationships

When design for social VR, it is important to first select what type of relationships to design for. People have different requirements for different types of social relationships. For example, intimate feeling is required for close relationships such as families and friends. According to the interview, social virtual reality has strong potential for close relationships. The Facebook Space and several other chatting room products were believed to be good tool for family gatherings. Apart from that, decentralized small social circles are preferred.



Fig 41 Social islands for different relationships

Define the added social values

After the selection of certain relationships, it is important to define the added value to people's social relationships. Designers need to understand what people want for the social relationships and design the right activities to meet their requirements. Understanding how people spend time together in the real world will help designers to choose the right activities. The following activities for different relationships are suggested by experiment participants. However, apart from activities that existing in the real world, designers should also think about the non-realistic activities that might be interesting for the users, which are able to address the advantages of social VR.

Friends: Exploring the natural, Room escape, Board games

Families: Virtual dining, watching movies, chatting room, theme park

Strangers: Gaming, Parties, Music festival

Colleagues: Presentation, co-creation, discussions, meetings



Fig 42 Do something meaningful together

Think about the social context

When designing for social activities, consider then social context. On the one hand, it provides people with the context to interact. On the other hand, the context also influences the type of people to meet and the types of relationships to develop.



Fig 43 Example of social context

Virtual and real world social

A balance between virtual social and real world social should be maintained. People are concerned that virtual social medias will make people less social, because people are actually alone themselves. The social VR should not be designed that people move all of their real world social into the virtual space. And it should not steal them away from their families and friends. Connecting online activities with offline activities will be a good choice.



Fig 44 Online shopping and offline product experience

5.2 Designing for quality of interaction

Smart recognition

Smart recognition for avatar can reduce the operation burden of the users. Facial expressions can be automatically recognized using artificial intelligence technologies. Hand gestures can be monitored with smart gloves, inside of controllers. If photo-realistic technologies are used, these might not be issues. However, I do recommend that the users should be allowed to switch between photo-realistic representations and avatars, sine they serves different purposes. For avatar, people feel safe to meet with strangers or explore something new. They also think it will be fun when used with friends. Photo-realistic representations are needed when people want some formal or intimate interactions.



Fig 45 Smart HMD that recognize the gestures

Augmented social interactions

Augmented social interactions allow people to better enjoy their social time. As indicated in the questionnaire, the wow factors in Facebook Space make people feel more excited and cheerful. However, these simple wow factors might disappear after using for sometime. Updating new features of interaction can improve people's social experience. Designers can think of adding 3D effects for different gestures, or enriching a moment with multi-sensory experiences. Emotional design can also be used to get people emotionally connected.

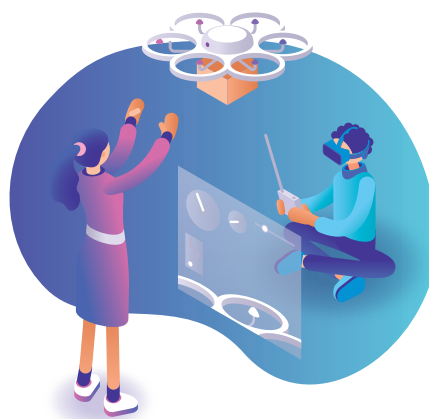


Fig 46 3D tools to enrich social interactions

Safety

Another important issue to consider is the safety issues. Some restrains should be designed to prevent people from misbehaving. Be transparent and make people feel in control of their personal information.

5.3 Designing for presence and immersion

On the one hand, make use of this advantage of social VR to provide unique social experience. For example, enable people to explore new experience that cannot be done in real life. On the other hand, since this experience is strongly influenced by the development of technology, designers should get updated about the new social VR technologies and make use of them to improve the quality of the products. For example, high quality images and less delay are preferred.



Fig 47 Explore the space with friends

PART 6 REFLECTING ON THE PROJECT

In this part, reflections on the whole project are provided. Suggestions for future research are given.

6.1 REFLECTION ON THE FRAMEWORK



6.2 REFLECTION ON THE EVALUATION METHODOLOGY



6.3 EXPLORING UX IN FUZZY FRONT END



6.1 Reflection on the framework

Through out the research, we try to explore what is social VR user experience in two different ways: literature research and user research. We started with literature research to explore the user experience definitions and frameworks for social VR. An initial ground understanding was gained. The user experience is directed influenced and elicited by the interactions with the system. Three factors influence the interaction and the user experience: system factors, user factors and context factors. Apart from context, the other elements in this diagram were all explored with research.

Interaction and experience

Firstly, the relationship between social interactions and social experiences were explored in a user research. A context mapping and a focus group were conducted to understand the important categories of social interactions and social experiences. Their relationships were mapped by user experience experts in an online survey: almost all the experiences can be elicited by certain social interactions. The relationships between interaction and social experience were used to help us cluster and define major dimensions of experience. Three dimensions of experience were found: Quality of interaction, social meanings and presence and immersion. Since this methodology has no strong literature support, the findings need to be further verified. Therefore, we conducted another literature research to identify important dimensions of experience, based on related research in the field of social communication and virtual reality. The current state of art matches with our finding generally, with some small differences. These differences help us better refine our definition of different dimensions of experiences.

Although the detailed relationship between social interaction and social experience cannot be fully understood, a close link can be inferred from the research findings. Using the relationship between interaction and experience does help to cluster experience in a meaningful way.

System factors and experience

The relationship between system factors and experience were explored in the experiment. Three types of systems with different features were selected: Face-to-face (no system), Skype and Facebook Space. Significant different among the three conditions were found for the three dimensions of experience. This indicates that the system factors do have a significant impact on the social experience. Also the experience of having a system in between differs from non-system conditions. However, in this experiment we only test different systems, and future research can try same system with different designs to check if the impact on user experience is still significant.

User factors and experience

Since the main purpose of the experiment is to compare different systems, the user factors and context factors were controlled. However, for the user factors we only control their relationships: two people who know each other well. There are still some differences among different pairs of participants. Firstly, there are three types of pairs considering the gender issues: male-male, female-female and male-female. We analysis the influence of this factor on the user experience, and no significant influence on the three dimensions of experiences were found. The social experience was not sensitive to gender differences. Another factor was the length of relationship: how long they know each other. Significant influence was found for the dimension of social meaning: people know each other more than 5 years scored significantly lower social meaning for each of the conditions. These findings indicate that people knowing each other long enough might have higher standard for social meanings. To conclude, the user factors do influence the social experience to some extent, but more studies need to be done to find the detailed relationships.

Context factors and experience

Due to the limitation of time and effort, we only studied one social context in this research: two friends sharing photos with each other. The reason for choosing this context can be found in PART 2. One of the drawbacks of using only one social context is that research findings cannot be universally applied. However, I try to make up for this the drawback by conducting literature studies to make it as generalized as possible. Nevertheless, further researches need to be done in order to verify all the findings.

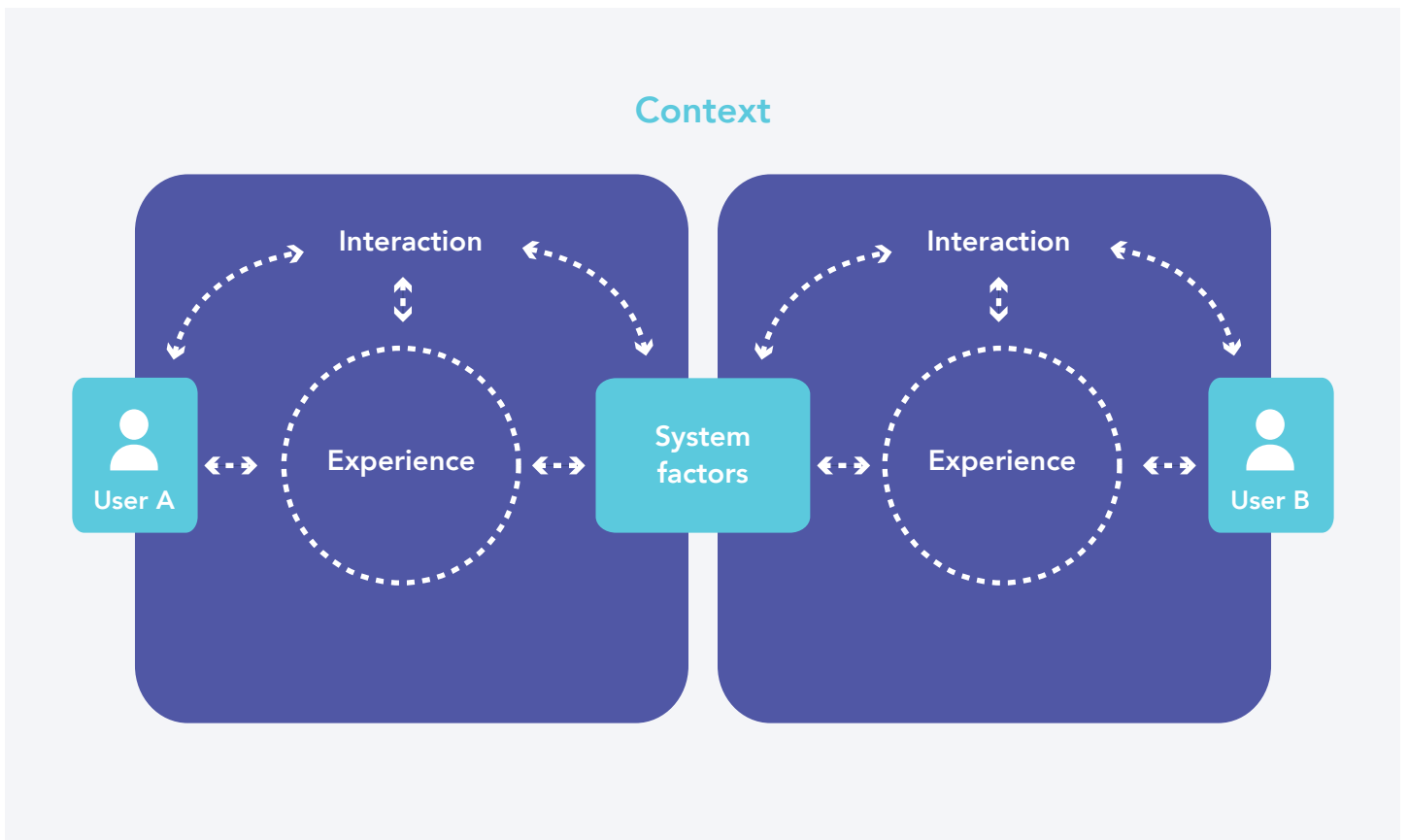


Fig 48 The updated understanding of social VR user experience

6.2 Reflection on the evaluation methodology

In this research, we proposed a user experience evaluation methodology for social VR. This methodology was designed according to user research findings and literature research findings. And it is tested in an experiment. The questionnaire was verified with factor analysis and internal consistency analysis. And the scales were sensitive to the different conditions in the experiment. The interviews went well and the result helps us to address the detailed problems.

The combination of quantitative and qualitative methodologies is effective for identifying problems. On the one hand, the quantitative part helps us to compare different conditions and draw general conclusion. On the other hand, the interview helps to identify the reasons behind the quantitative scores and discover the user's feelings.

6.3 Exploring UX in fuzzy front end

This research was conducted in one of the fuzzy front-end fields: social virtual reality. The technology of social VR is still being developed, and a lot of systems are being developed to try out the technology. However, there's no clear understanding about what the user want from this technology and what values it can bring to the users. It is really a challenge for designers to understand the user experience in such a field. There's no standard design theories or methodologies to be used. Designers need to try out different methodologies to solve problems rise in this field. The exploring process help designer to understand this field and establish some common methodologies.

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