

Being close but at a distance

Social interaction in an immersive Virtual Reality environment

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ABSTRACT

Mediated communication has been around for years. Since Web 2.0, it has been used to communicate via text-based, audio-visual information communication. Over the last few years, the emergence of the Metaverse, the third generation of the World Wide Web (Web 3.0), has taken mediated communication to the next step. By conveying verbal and non-verbal behaviour through positional tracking and stimulating other senses such as touch (feeling), immersive Virtual Reality (IVR) seems to offer the possibility of deepening social interaction through mediated environments. Perhaps even moving towards social interaction resembling face-to-face communication. This raises the question: "How do users experience social interaction in an immersive VR environment?"

The question is answered using the social interaction model Kreijns et al. (2022) proposed. This model consists of the three concepts social presence, sociability and social space. The research subsequently tested the model by means of a qualitative experiment, in which five couples ($N = 10$) were put in an immersive VR environment. Afterwards, through in-depth interviews, they were asked about their experiences regarding interaction with each other and the environment.

What emerged was that social presence - the 'realness' of a person - is partly perceived by, on the one hand, the technological affordances for the transmission of non-verbal and verbal cues and, on the other, the social affordances offered by immersive VR, such as the possibility of playing a game. Positional tracking also appears to contribute to social interaction; through characteristics such as the height of the other participant, some form of recognition takes place. The prerequisite is that an interpersonal relationship is already present before participants experience social interaction in an immersive VR environment.

However, the analysis shows that due to the current flawed state of immersive technology, social interaction in an immersive VR environment is still far from resembling face-to-face communication. Nevertheless, a high level of presence was observed during this research, mainly via interaction with both the other person and the environment. The research concludes that even though no immersion takes place, the users can still experience presence.

KEYWORDS: *immersive VR, Social Interaction, Social Presence, Haptic feedback, verbal and non-verbal cues*

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1. Introduction

Mediated communication has been around for years. Since the advent of Web 2.0, it has been used to communicate via text-based, audio-visual information communication. Over the last few years, the advent of the third generation of the World Wide Web (Web 3.0) has taken mediated communication to the next step by offering the possibility of also communicating by transmitting verbal and non-verbal cues through positional tracking and offering additional sensory information, such as touch through haptic feedback.

Web 3.0 is considered the cornerstone of the Metaverse. The Metaverse can be described as an immersive Virtual Reality (immersive VR) space in which users can interact within a computer-generated environment with other users. Web 3.0 is a virtual environment still in development (Bonifac, 2021), where the boundary between physical and virtual reality is increasingly blurred and questioned. Social spaces in Web 3.0 are also referred to as immersive VR platforms (Tanenbaum et al., 2020). What makes these platforms interesting is that they facilitate social interactions between users through virtual reality headset displays (McVeigh-Schultz et al., 2018).

Immersive VR technology increased the potential for mediated communication and social interactions because it can stimulate the senses of people in the virtual world. Although brain-computer interfaces will eventually have to provide an experience as ‘real’ as possible (van Noort, 2022), at the moment, Virtual Reality is the name of the technology that stimulates the senses in the virtual world. In a 2D computer environment, this only involves the perception of text-based communication or through images and sound. In the 3D virtual world, other senses and emotions can also be stimulated, such as the sense of touch and verbal and non-verbal cues received and perceived through positional tracking (Maloney & Freeman, 2020). One question that arises from these new developments is whether this novel system can shape social interaction in a mediated environment.

This thesis aims to get more insights into the social interactions between users within an immersive VR environment. It is the result of a qualitative experiment in which social interaction within the virtual environment is investigated using a Head Mounted Display (HMD), controllers and a haptic feedback technology vest, making it possible to experience touch in a virtual environment. The experiment is conducted in the form of dyads, in order to get more insights into the social interactions between the participants.

The starting point of this thesis is the theoretical framework concerning social interaction as proposed by Kreijns et al. (2022). A crucial concept in the literature concerning mediated social interaction is social presence. Social presence has been defined and theorised in many ways: it was first defined by Short et al. (1976) as “the degree of salience of the other person in the interaction and the consequent salience of the interpersonal relationship” (p. 65). However, as technology developed, this rather technological deterministic definition became outdated and insufficient due to the

possibility of also using non-verbal gestures in real-time communication practices that can also generate audio-visual content. Therefore, more social-constructivism-centred definitions rose.

Kreijns et al. (2022) tried redefining social presence theory by considering both perspectives. By redefining social presence, they entangled two other interrelated but different concepts: sociability and social space. Kreijns et al. (2022) studied social interaction in a mediated environment from a Human-Computer Interaction (HCI) perspective, which focuses on the 2D interfaces between users and computers. Is the social interaction model also applicable to social interaction in a 3D immersive VR environment, or does it not suffice? How does one experience themselves and the interactions with others in this second reality with the current virtual reality techniques used? Does a shared reality emerge? Can immersive VR lead to the same shared experience of meaning and value as in the physical world?

This paper tries to address the above-mentioned questions by exploring the following research question:

RQ: How do users experience social interaction in an immersive VR environment?

To answer the research question and structure the study, three sub-questions were derived:

SQ1: How do users experience social presence in an immersive VR environment?

SQ2: How do users experience sociability in an immersive VR environment?

SQ3: How does the social space influence social presence in an immersive VR environment?

These subquestions are shaped around the three concepts that contribute to social interaction according to Kreijns et al. (2022). The first sub-question will answer what defines social presence and what determines the ‘realness’ of the other person in an immersive VR environment. The second sub-question will answer how the medium attributes of the immersive VR environment can contribute to social interaction. The last sub-question will explore in what ways social factors influence how social presence is perceived.

The answers to these questions are important for understanding how these immersive VR technologies relate to social interaction and the ability to mimic face-to-face communication. This is relevant because when mediated social interaction comes closer to real-life social interaction, the technology may blur the boundaries between the physical and virtual worlds, eventually challenging our perceptions of space and time.

1.1. The academic and societal relevance

This research derives its academic relevance from several aspects. First, mediated social interaction has been a research topic for many years (Short et al., 1976; Walther, 1993; Biocca & Levy, 1995; Gunawardena, 1995; Lowenthal, 2010; Kreijns et al., 2022). However, until now there are many different definitions of social interaction and incompatible measures to assess it, let alone in an

immersive VR environment. Therefore, this research will explore the concept of social interaction through the social interaction model as proposed by Kreijns et al. (2022) in order to extend existing literature on social interaction in a mediated environment.

Second, this research is focused on social interaction in an immersive VR environment, which offers additional sensorial information such as haptic feedback, and the possibility to transfer non-verbal and verbal cues by positional tracking (Fermoselle et al., 2020). Existing literature has investigated the influence of haptic feedback (Fermoselle et al., 2020), or positional tracking in relation to the transmission of verbal and non-verbal cues (Desai, 2014). However, none of these studies do so using the social interaction model of Kreijns et al (2022). In this regard, this thesis will bring new insights into the research field (Carr & England, 1995).

Third, most research conducted on Virtual Reality concerns e-learning (Kreijns et al., 2022; Freina et al., 2015), museum experiences (Carozzino, 2010) or gaming purposes (Tao, 2021). This research focuses on how an immersive environment can enhance mediated social interaction, a research field that remains to be further explored. Therefore, this research broadens the scope of the existing literature on immersive VR by highlighting its potential for social interactions between users.

The social relevance of this research lies in exploring the possibilities that 3D immersive VR environments can offer for mediated communication in this early stage of the technology. Social interaction in an immersive environment can potentially provide remote education to a wider audience (Kreijns et al., 2022), reduce loneliness (Maloney & Freeman, 2020) and help maintain relationships (Tanenbaum et al., 2020). In addition, social interaction through immersive VR environments provides the opportunity for people who, for whatever reason, are place-bound and do not have the freedom to go wherever they want in the physical world. These virtual environments thus potentially can help overcome disabilities or physical boundaries (Beach & Wendt, 2014).

1.2. Chapter outline

After this introductory chapter, chapter two will present the theoretical framework, in which first, a number of distinguishing features and related concepts of immersive VR will be discussed. These distinguishing features are *transferring non-verbal gestures through positional tracking*, *animated representation* and *haptic feedback*. Next, the social interaction model proposed by Kreijns et al. (2022) will be discussed based on the concepts of *social presence*, *sociability* and *social space*. Then, the concepts of immersion and presence will be discussed.

In the third chapter, the research methods will be described. First, the sampling method will be discussed. Next, the operationalisation will elaborate on how concepts are made measurable. Third, the choice of methods and in-depth interviews will be discussed. Then, the choice of qualitative methods and in-depth interviews will be discussed. After, the thematic analysis is discussed. The chapter closes off with validity, reliability and ethical matters.

In chapter four, the findings and discussions of the analysis are presented, discussed and placed in context. The results are presented according to the three sub-questions of the study in order to ultimately answer the main question in the conclusion. Next, two other themes derived from the analysis will be discussed. In the final chapter of this research, the most important findings will be summarised and applied to answer the research question. Also the limitations and future research will be aleborated on.

2. Theoretical framework

This chapter presents the theoretical framework, which forms the foundation of the research. To explore how social interaction in an immersive VR environment is perceived, it is essential to delineate key concepts from the problem statement and research questions. Therefore, it is important to provide an explanation of the important concepts, elaborate on definitions of terms and explain the essential theories and models. First, this chapter will elaborate on immersive VR by defining its key features and important relating concepts regarding social interaction. Next, the chapter will elaborate on the social interaction model proposed by Kreijns et al. (2022) according to the three concepts of *social presence*, *sociability* and *social space*.

2.1. immersive VR

This research's aim is to investigate social interaction in an immersive VR environment (immersive VR environment). This section defines immersive VR and highlights its distinguishing features. immersive VR is an artificial environment that is designed to completely immerse the user in the computer-generated space. immersive VR's goal is to provide the users with a real or almost believable experience (Furht, 2008) so that the user has the impression they step inside a realistic environment.

Users in an immersive VR get the feeling that they are stepping into a 'synthetic world' when they enter the computer-generated world by using HeadMounted Displays (HMD). These goggles project a virtual reality in front of the users' eyes. The HMD contains magnetic sensors that detect head movements. The user's field of vision changes as they move their head (McVeigh-Schultz et al., 2018). Because body movements are measured by the HMD, the representation of someone moves along with the behaviour of the user in real life.

immersive VR has several features that distinguish the technology from other forms of mediated communication, such as *transferring non-verbal gestures through positional tracking*, *animated representation* and *haptic feedback*. These three concepts will be briefly explained below.

Transferring non-verbal gestures through positional tracking: signals in a social context (non-verbal cues such as posture, gesture, or touch) positively influence the satisfaction of the quality of communication (Aubert & Kelsey, 2003). In the broadest sense of the word, these non-verbal behaviours refer to behaviours that do not fully contain linguistic content (Knapp et al., 2013). That means that relevant information is communicated in a non-verbal way. Nonverbal cues can help guide and understand communication in the context in which it is shared (Lausberg & Sloetjes, 2009). Previous research has shown that there are generally four distinct non-verbal gestures: facial behaviour, gaze, gestural behaviour and spatial behaviour (Baxter et al., 1968; Lausberg & Sloetjes, 2009).

Verbal and non-verbal cues are an important feature of social interaction in face-to-face interaction (Hinde & Hinde, 1972), and have been proven beneficial in a mediated environment (Short et al., 1976). Because body movements are measured by the HMD, the representation of someone moves along with the behaviour of the user in real life. This makes it possible to convey verbal and non-verbal behaviour in a natural way.

Immersive VR makes possible natural embodied interactions through verbal and non-verbal cues. In an immersive VR environment, the body is positionally tracked. Position tracking detects the precise position of head-mounted displays, controllers, other objects or body parts. In order for social interaction to feel ‘real’ or as naturally as possible, it is of utmost importance that position tracking is both accurate and precise, so as not to break the illusion of three-dimensional space (Desai et al., 2014).

Avatar-mediated communication: Previous research has shown that the use of a virtual representation (avatar) also influences mediated communication (Becker & Mark, 1998; Friedman et al., 2007; Maloney et al., 2020; Maloney & Freeman, 2020). When communicating through immersive VR, the main difference in comparison to face-to-face interaction is the use of avatars as a proxy for all communicators (Manninen & Kujanpää, 2007). An avatar can have different degrees of human-like appearance. For example, there are cartoon-like avatars, which are more reminiscent of fantasy creatures. But there are also other forms of animation that have more resemblance with real life persons and objects.

A recent invention in the field of digital representation is the digital twin (Jones et al., 2020). A virtual digital twin is equivalent to virtual digital reality. To create a digital twin, three components are necessary: a physical product in the real environment, a virtual product in a virtual environment and connections of data and information that link the virtual and physical products (Jones et al., 2020).

A digital twin can be described as the virtual representation of something that exists in the physical world. In this regard, a digital twin is also an avatar, because characters in immersive VR are virtual and not real. For this study, reference is made to animated avatars, that is a cartoon-like figure that has little to do with the person’s appearance.

Haptic feedback: an important feature of immersive VR is the ability to add sensory information that goes beyond audio-visual content, notably by engaging the sense of touch. Research around haptics is emerging and concerns the development of algorithms and software that use the sense of touch (El Saddik, 2007). Haptic technology refers to the technology that simulates the sense of touch of users in immersive VR. Haptic technology is based on algorithms that detect and rapport when and where tactile contact occurs (collision detection) and calculates real-time interaction-feedback for the haptic device (Burdea, 1999).

Rasool et al. (2021) argue that adding multi-sensory affordances beyond audio-visual content enriches storytelling and creates more narrative engagement. Adding haptic technology can also potentially positively influence social interaction, by stimulating the sense of touch (Fermoselle et al., 2020).

2.2. Social Interaction

This section will extensively lay out the different dimensions of social interactions. Erving Goffman (1991) first described social interaction as a new field of study and defined it as people their actions and reactions towards each other. Mediated communication refers to the use of any technical medium for transmission across time and space. Technology has become more sophisticated and understanding social interaction through media devices has become more complex due to the Internet.

This research explores social interaction in an immersive VR environment by using the social interaction model proposed by Kreijns et al. (2022). It should be mentioned that Kreijns et al. (2022) based their model on interaction in a 2D computer-mediated environment. However, due to the fact that the range of definitions of social presence and social interaction is so diverse and often outdated, the conceptualisation of Kreijns et al. (2022) has been identified as the most suitable measure for this research. Although their model focuses on social interaction in a 2D computer-generated environment, it takes into account both group attributes and medium attributes. Due to the ability to communicate through verbal and non-verbal cues through audio/visual attributes, it is important to consider the social factors as well.

They designed the social interaction model to offer a way out in the diverse landscape of theories on social presence. However, while entangling social presence, Kreijns et al. (2022) discovered two interrelated concepts: *sociability* and *social space*. According to Kreijns et al. (2022), these three concepts (*social presence*, *sociability* and *social space*) define social interaction in a mediated environment. These concepts cannot function separately and all influence one another.

Social presence has long been analysed from a technological determinism perspective, which only considered the medium's capabilities to transfer communication (Short et al., 1976). However, as technology became more advanced, and with the rise of the internet, it has been argued that social presence should not only be approached from a technological determinism perspective but should also consider the influence of someone's social situation (Kreijns et al., 2022).

According to Kreijns et al. (2022), social presence, sociability, and social space are interrelated and cannot function separately. Social presence refers to "the 'realness' of the other person in the interaction" (p. 139). Social space focuses on the interpersonal relationship between the communicating actors. Lastly, sociability concerns the technological affordances of devices to allow for social presence and the emergence of social space.

Kreijns et al. (2022) visualised the social interaction model to understand their concept and measurement of social presence. The triangle showcases the interrelations between sociability, social

space and social presence. Social interaction is positioned in the middle of the triangle to illustrate that all three constructs influence social interaction. The triangle is presented in figure 1. The next sections develop these three constructs in more depth.

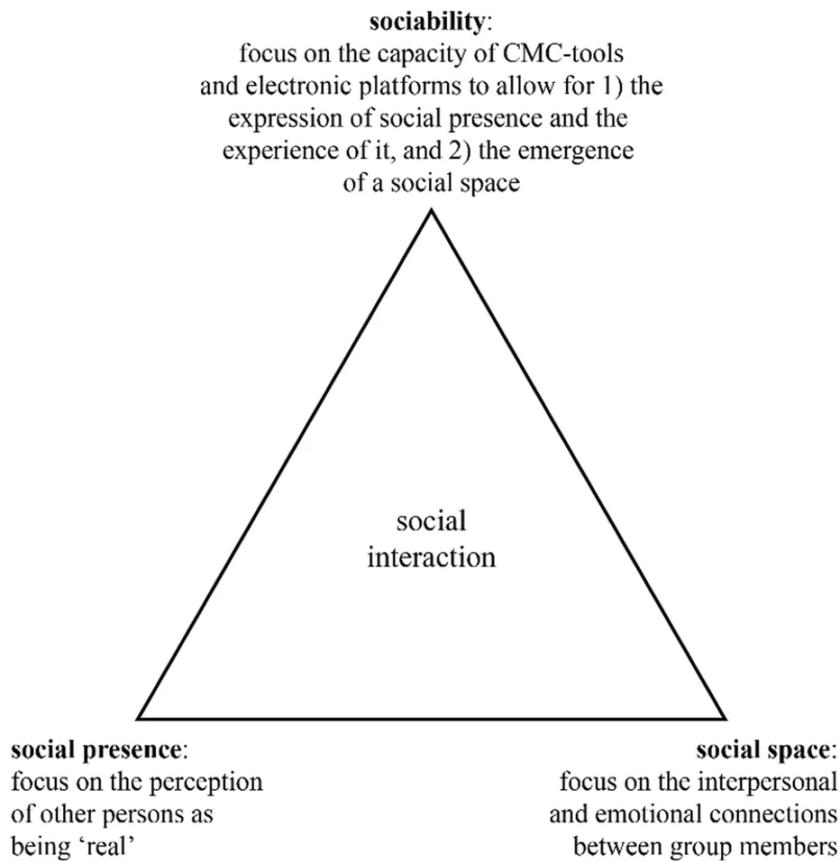


Fig. 1. The social presence, sociability and social space triangle as proposed by Kreijns et al. (2022)

2.2.1. Social presence

The social interaction model is the result of detangling social presence, and therefore this section firstly elaborates on the latter. When analysing social interaction in a mediated environment, scholars have perceived social presence as a central concept (Aragon, 2003; Argyle & Dean, 1965; Gunawardena, 1995; Short et al., 1976; Wiener & Mehrabian, 1968). Social presence is considered in relation to the degree to which a person is perceived as “real and present” in a given mediated communication (Short et al., 1976; Kreins et al., 2022). The concept is essential for the understanding of social interactions, yet there are many different perspectives on how to define and measure social presence.

Social presence was firstly defined by Short et al. (1976). They perceived social presence as the ability of telecommunication devices to represent the communicator as realistic as possible. According to Short et al. (1976), there were two types of behaviour of social presence: intimacy and

immediacy. Intimacy and immediacy refer to the psychological distance between two communicating actors and nonverbal and verbal behaviour in a mediated environment. Short et al. (1976) defined social presence as:

The degree of salience of the other person in the interaction and the consequent salience of the interpersonal relationships [...] [Social presence] varies between different media, it affects the nature of the interaction and it interacts with the purpose of the interaction to influence the medium chosen by the individual who wishes to communicate [...] social presence [is] a quality of the medium itself (p. 65).

According to their definition, social presence is mainly dependent on the medium. By focusing on the affordances of the medium, they ruled out other factors shaping the experience of perceiving the other person as “real”. This is not surprising since technology at the time was not as advanced and, more specifically, not time-synchronous as it is now.

However, a few years later, Gunawardena (1995) argued that social presence was not just a given but could also be created. While mostly focusing on social presence in computer-mediated communication, she stated that “even though Computer-Mediated Communication (CMC) is low in transferring non-verbal and social context cues, users can create a sense of social presence by projecting their identities and building online communities” (p. 163). Gunawardena thought of social presence in CMC as being determined by the user’s perception of the medium. Therefore, social presence was defined as being ‘social’ and not so much by the attributes of the communication medium itself.

In order for CMC to be social, real-time interaction was required. She therefore states that “immediacy enhances social presence” (p. 151). This can be interpreted as that real-time interaction would enhance social presence. This perception of social presence as not solely being a medium attribute started a whole new line of research focused on online education and online group learning (Aragon, 2003), social climate (Akyol & Garrison, 2008), perceived learning (Caspi & Blau, 2008) and community building (S. Y. Liu et al., 2009).

However, these new insights on social presence resulted in a spectrum of theories on social presence, defining the concept on the one hand from a technological perspective, on the other from a social determinism perspective, or somewhere in the middle. Lowenthal (2010) attempted to categorise the definitions of social presence by classifying them as, on one hand, focused on “realness” and being present. On the other hand, he focused on definitions that emphasised the interpersonal connection between communicators. According to Lowenthal (2010), all existing definitions until then are somewhere on the spectrum, but none of the definitions does justice to the concept of social presence.

These definitions categorised as ‘real’ overlap with the definition of social presence made by Kreijns et al. (2022). Definitions that emphasise interpersonal connection are related to the concept of social space. These two concepts will be elaborated on further in the following sections of the theoretical framework chapter.

All these additional measures of social presence make it difficult to compare the research results with each other. Moreover, even if the dimensions - correlations - are the same for different measures, they can still be defined differently, which results in outcomes that mean the same thing but are fundamentally different.

Because of the difficulties mentioned above surrounding social presence theory, a demand for a uniform way of defining and measuring social presence rose. Kehrwald (2008) suggested it, however no one has followed up on it until today. Due to the amount of different definitions within social presence theory, it is often suggested to let go of social presence theory (Öztok & Kehrwald, 2017) or to conduct more uniform research that will identify effective instruments to measure to create a good conceptualisation than social presence, with correct instruments (Cui, 2013).

Therefore, Kreijns et al. (2022) tried to redefine social presence by going back to the first definition of social presence proposed by Short et al. (1976) in order to re-consider social interaction in the current media concerning novel technology systems.

To get a better understanding of the rather abstract concept, they proposed to split Short et al. (1976) their definition of social presence into two: (1) “the degree of salience of the other person in the interaction” and (2) “[the degree of] salience of the interpersonal relationship”. The first part of the definition (1) relates to the definition of social presence of Kreijns et al. (2022); the latter (2) is related to their definition of social space.

This resulted in a reformulation of social presence, defining it as “the psychological phenomenon in which, to a certain extent, the others are perceived as physical “real” persons in technology-mediated communication” (see also: Weidlich & Bastiaens, 2017, 2019). Kreijns et al. (2022) thus, simply put, define social presence as the realness of the other person. As they explain in their paper, “ultra-realistic avatars would be entirely in line with what social presence is” (p. 25). This research was conducted with only a representation of animated, fictitious avatars.

To study social interaction in a social virtual environment, the definition of presence as proposed by Kreijns et al. (2022), together with the definitions of sociability and social space, are used. As stated above, intimacy and immediacy concepts are related to perceiving the other communicator as “real”. Intimacy and immediacy in their turn define “realness” and are shaped by verbal and non-verbal cues. Since immersive VR can generate positional tracking and naturally embodied non-verbal cues, it is worth exploring the sense of social presence in an immersive VR environment. Therefore, the first sub-question derived is:

SQ1: How do users experience social presence in an immersive VR environment?

2.2.2. Sociability

Short et al. (1976) saw social presence from an entirely technological perspective, meaning they defined the concept as if the medium's technological properties determine the degree of social presence. They measured this with a bipolar scale consisting of four dimensions: (1) unsociable–sociable, (2) insensitive–sensitive, (3) cold-warm, and (4) impersonal–personal. However, the scale was never verified as measuring the other person's authenticity (Short et al., 1976).

Kreijns et al. (2022) assume that this scale measures another construct called *sociability*. They define sociability as “the capacity of CMC tools and electronic platforms to allow for 1) the expression of social presence, the experience of it, as well as for the 2) emergence of a social space. Sociability is a capacity of CMC tools and electronic platforms, and as such, sociability is a medium attribute” (p. 159).

Since this is a rather lengthy definition, it should be split into two to better understand the meaning. The first part of the definition states, “Sociability is the capacity of CMC tools and electronic platforms to allow for the expression of social presence”. In other words, sociability is the capacity of CMC tools and electronic platforms to allow for the expression of “realness” of the other person as well as the experience of it.

Allowing for the expression refers to the attributes of a medium able to transmit “realness”. Transmitting realness can be perceived through physical attributes of the medium and through social attributes of the medium. The physical attributes of the medium are the devices that allow transmitting sensory information.

“Realness” in computer-mediated communication can also be perceived through social affordances. Since sociability is an attribute, it can be designed. According to Kirschner and Kreijns (2005), the social affordances of a medium determine sociability, which means the technological attributes must also have a social function. An example of a device with social affordance is a coffee machine in a work environment, where employees meet and casually talk about easy topics.

These small social moments contribute to the interpersonal relationships between users and are essential in a mediated environment. In the case of virtual reality technology platforms, the affordances are, for example, reducing overcoming physical limitations, reducing emotional risk, enabling physically incapable participants, and overcoming space-time linearity (Steffen et al., 2019). In the case of immersive VR, a social affordance could be the ability to perform social actions, e.g., playing a board game in the virtual environment. Social affordances are essential for social interaction in a mediated environment.

The second part of the definition refers to the capacity of CMC tools and electronic platforms to foster the emergence of a social space. These social affordances also relate to the second part of the definition of sociability proposed by Kreijns et al. (2022) since they determine the potential of the medium for the emergence of social interaction. The following section will elaborate on social space, but for now it is sufficient to understand social space as a groups attribute.

Sociability as defined by Kreijns et al. (2022) is in line with the social information processing theory as theorised by Walther (1993), which is about how people get to know each other. Impression formation and impression management are part of Walther's theory that has been adopted in the theory of Kreijns et al. (2022). Impression formation has to do with how impressions are formed towards someone else and the other way around by using verbal and non-verbal cues (Maloney et al., 2020; Maloney & Freeman, 2020).

The theory suggests that even if one cannot use all the non-verbal cues, people adapt to the medium's restrictions by looking for clues in the language they use and adapting their emotional and social expressions to the available language (Walther, 1993). This theory has previously been applied to communication on the text-based web in relation to the addition of emoticons to convey emotions. Now, with the advent of immersive VR, this theory could be applied to the possibility of using verbal and non-verbal behaviour, if in an animated environment, to convey emotions as well.

In short, sociability is a medium attribute, and it concerns the ability to convey 1) social presence and 2) social space. This research assumes that conveying social presence and social space is done to some extent through verbal and non-verbal behaviours, and 2) social affordances. Therefore, the second sub-question is:

SQ2: How do users experience sociability in an immersive VR environment?

2.2.3. Social Space

As mentioned above, the definition of social presence as proposed by Short et al. (1976) is “the degree of salience of the other person in the interaction” and secondly, “[the degree of] salience of the interpersonal relationship”. Here the former is the cause of the latter and vice versa. Kreijns et al. (2022) approached these two definitions as separate from each other and as two interrelated but different constructs. The second part of Short's definition is rephrased and reformulated and it concerns the group characteristics (attributes) that influence social interaction.

As described by Kreijns et al. (2022), social space is seen as “the network of interpersonal relationships embedded in group structures of norms and values, rules and roles, and beliefs and ideals. A healthy social space manifests itself in the sense of community, group climate, mutual trust, social identity and group cohesion. As such, social space can be seen as a group attribute” (p. 159).

Kreijns et al. (2022) describe a social space as both a spatial and cultural environment. Spatial in the sense of different structures and social groups in which a person finds themselves, think of family, friends, work relations, teammates, and colleagues. These can be strong or weak, all occupying a particular place. This notion of relational ties claiming a specific place derives from the Social Network Theory (SNT) (Katz et al., 2004; S. Y. Liu et al., 2009; W. Liu et al., 2017; Q. Liu &

Steed, 2021). Social space is seen as a cultural environment in a sense regarding norms and values and beliefs shaped and maintained by group members (Kreins et al., 2022).

In Social Network Theory, actors, the position in the network and the network's structure are valuable. Actors tend to group with similar characteristics, interests or thoughts, theories and assumptions. These actors coordinate their behaviour and make it compatible with the network, or the network influences them to behave in a certain way.

Social space is related to the concept of social connectedness. Van Bel et al. (2008, 2009) developed a conceptual framework that makes it possible to measure the subjective experience of belongingness and relatedness when using communication systems. Based on previous research, they have introduced the umbrella term social connectedness.

Van Bel et al. (2008) define social connectedness as "the momentary affective experience of belonging to a social relationship or network". They developed the construct to address experiences along five dimensions that differ from subtle experiences to richer interactions. The dimensions of social connectedness are the following: (1) relationship saliency, (2) closeness, (3) contact quality, (4) knowing each others' experiences and (5) shared understanding. These dimensions come down to the same characteristics as social space.

In addition, one of the pioneers of Social Network Theory (SNT) is Mark Granovetter (1973). In his social science paper published in 1973, he stated that there are strong and weak relational ties in social networks. Strong ties characterise deep affinity, for example, family, friends, loved ones or colleagues. Weak ties are acquaintances or strangers. The strength of these ties can substantially affect interactions, outcomes and well-being. Research conducted by Van Bel et al. (2009) showed that the scores on social connectedness in the friend condition were significantly higher than a distant acquaintance.

Kreijns et al. (2022) also assume that a sound social space has a positive influence on social interaction in a mediated environment. When examining social interaction in a virtual environment, it is worth taking the interpersonal relationship into account. When two communicators already know each other in the physical world, it is easier to recognise characteristics and behaviour in a virtual environment. Thereby, it is beneficial for this research to investigate from the point of view of an interpersonal relationship that already exists in the first place, so that recognition of the other (which contributes to authenticity) is more easily encouraged.

In short, all these interpersonal relationships are either weak or strong. Kreijns et al. (2022) state,

These bonds are embedded with norms and values, rules and roles, and beliefs and ideals. [...] communicating individuals may experience a shared social identity, group cohesion, connection with others, mutual trust, a sense of belonging, a sense of community, a social climate and an open atmosphere. These together constitute the social space (p. 159).

As proposed in the previous sub-section, sociability is partly determined by the capacity of CMC tools and electronic platforms to contribute to the emergence of a social space. In this sense of the concept, it is about the ability of the medium to construct a social space through the medium attributes. These medium attributes are referred to as social affordances.

In order to investigate to what extent interpersonal relationships influence the “realness” of other participants, it is helpful to consider these actors and their properties. When these properties exist in a positive sense, there will also be a positive effect on the interaction between people in a virtual environment (Kreijns et al., 2022; Van Bel et al., 2008, 2009). Therefore, the third and final sub-question of this paper is:

SQ3: How does the social space influence social presence in an immersive VR environment?

2.2.4. Presence and immersion

The following section will elaborate on the two concepts of presence and immersion. When researching immersive VR, these two concepts are essential for understanding what the technology is about. Building on Kreijns et al. (2022) definition of social presence (the “realness” of the other participant), presence is defined as the “realness” of the overall experience. The concept of presence is related to but differs from the concept of immersion. Making a distinction between the two concepts provides a better understanding of the difference between the psychological experiences made possible by mediated communication and the technological qualities (Oh et al., 2018).

Presence is defined as the subjective experience of being present in a virtual environment (Walther & Parks, 2002; Witmer & Singer, 1998). Presence is necessary in order to fully experience a virtual environment and regards how someone feels themselves inside the virtual world (Cummings et al., 2012). In order to obtain a subjective experience, there must be a certain interaction with something or someone. If the environment offers social interactions that are natural to the user, it will seem more real; if interaction with the virtual environment is easy and natural, it strengthens presence (Oh et al., 2018). Presence therefore has to do with the features that the virtual reality environment offers, which make this interaction possible.

Immersion is a description of the technology and describes to what extent technology is able to trick someone into feeling that they are somewhere else. In that regard, immersion can be objectively measured by what the technological medium is capable of; immersion is a medium attribute. Media are immersive when they provide “an inclusive, extensive, surrounding and vivid illusion of reality to the senses of a human participant” (Slater & Wilbur, 1997, p. 606). Immersion is about the sensorial information that gives the impression of being somewhere else; it refers to the realness of the experience. Such sensorial information includes audio and visual quality (Skalski et al., 2009; Skalski & Whitbred, 2010; Cummings & Bailenson, 2016) and haptic feedback (Fermoselle et al., 2020).

To conclude, Mel Slater (2003) distinguishes both concepts the following: “Immersion refers to the objective sensory fidelity the system provides. Presence refers to the users subjective psychological response to a VR system.” (p. 2). Ideally, immersive technologies allow for presence. Immersion is an act, rather than a state of being. Therefore, immersive technologies can be labelled as technological affordances for presence.

3. Methodology

This chapter will explain the methodological choices in the empirical part of this thesis. The first paragraph will explain the set-up of the experiment. Next, the choice for qualitative research will be elaborated on. Then the implementation of the in-depth interviews will be discussed and explained, together with the choice for thematic analysis. Third, the recruitment process will be elaborated on, wherein the selection of the respondents will be covered. After that, the operationalisation of the research will be discussed. The last section will cover the validity, reliability and ethical matters.

3.1. The set-up of the experiment

This study concerns social interaction in an immersive VR environment. In order to investigate the relationship between social interaction and immersive VR, the research design was a qualitative experiment. This experiment was held at *The Leids Virtuorium*¹ with 10 participants from 20-04-2022 to 15-05-2022. The experiments were conducted on four different days within this time period. *The Leids Virtuorium* is a virtual reality base in Leiden, the Netherlands, where virtual reality experiences are offered for commercial and research purposes. Before the start of the experiments, several meetings were held at *The Leids Virtuorium* with Virtual Reality experts to determine the most suitable research set-up to test social interaction in an immersive VR environment.

To investigate the social interaction between the participants in an immersive VR environment, the participants were placed in the same virtual environment in two separate physical rooms. This virtual environment was made possible by *VRchat*², an online virtual world platform. The platform allows users to interact with each other using user-created 3D animated avatars. Because the study focused on interpersonal communication between the participants, the social mode was turned off. The participants were therefore only present in the virtual environment together.

To enter the virtual environment, participants were provided with different technologies. The participants wore a haptic vest with six pressure points at the front, controllers and a Head Mounted Displays. The Haptic vest that the participants wore during the experience is the TactSuitX16, designed by bHaptics³, the Head Mounted Displays together with the controllers were provided by Valve-Index⁴. These goggles were attached to the ceiling of the physical room, and all participants had one square meter to move around freely. When the participants stepped out of the square, a notification appeared on the screen for safety purposes.

The aim of this study was to investigate social interaction through immersive VR, and see if the extra affordances offer a more natural experience. Therefore, every effort was made to make the experience as natural as possible. That is why the participants were placed in a cafe-like setting that resembles a café in the physical world, including a bar, tables and chairs. The virtual environment

¹ <https://virtuorium.nl/>

² <https://vrchat.com/home/>

³ <https://vrchat.com/home/>

⁴ <https://vrchat.com/home/>

consisted of an indoor and outdoor area with various attributes such as a pool table, a couch with cushions and a television with a remote control. The participants could interact with all the attributes in the immersive VR environment: they could for example pick up the cushions, switch the light on and off, draw the curtains and play a game of pool together.

To research social interaction in the immersive VR environment, the participants were always placed in the virtual environment in pairs. At the beginning of the experience, participants were given a few tasks to complete: they had to try to pick up and throw an object, look in the mirror and try to hug each other.

The naturalness of the interaction with the virtual environment was tested by picking up and throwing objects. The participants were asked to look into the mirror to see the reflection of their own virtual representation (avatar) as well as the reflection of the virtual representation of the other participant. Participants were asked to hug each other in order to stimulate their social interactions and test the haptic technology's capabilities. Apart from the above three actions, the participants were left free to do anything they wanted in the virtual environment in order to preserve as much as possible the naturalness of the interaction.

The researcher intervened as less as possible in order to maintain the naturalness of the experience. Therefore, even though the main method of this research is conducting in-depth interviews, observational notes were also made throughout the experiments.

3.2. Choice of method: qualitative research

This research aims to study individual experiences of social interaction in an immersive VR environment through the perspective of concepts of *social presence*, *sociability* and *social space*. It is essential to choose a method that is flexible enough to allow each interviewee the freedom to express their experiences in their own words. On the other hand, this method must also be structured enough to allow reconstructions of different formulations under a shared denominator (i.e. finding a shared ground for different formulations).

Qualitative methods are used to study experiences and perceptions, making them suitable for the current research (Boeije, 2010). Qualitative research is well suited to identifying views such as expectations and experiences of respondents (Boeije, 2010; Wester, F.P.J. et al., 2006). Qualitative methods are suitable for investigating experiences because they not only provide an objective overview of the research topic but also enable the extraction of deep contextual meaning-making (Geertz, 1973).

3.2.1. In-depth interviews

The main advantage of in-depth interviews is that they allow for collecting much more nuanced and detailed information about a given topic than any other method (Hermanowicz, 2002).

In-depth interviews help discover new insights and allow one to understand topics from another's perspective. Therefore, this method is highly suitable for measuring subjective experiences about abstract topics such as social interaction in an immersive VR environment.

The interviews were conducted in a semi-structured way. On the one hand, this way of interviewing offers the flexibility required to express oneself in one's own words; on the other hand, it structures so as not to stray too much from the topic and the research question (Boeije, 2010). By applying useful tools such as repeating the questions, asking for example to strengthen their opinion or repeating the last words of the participants' answers, it was probed to extract as much information from the participants as possible. Two pilot interviews have been conducted in order to improve the topic guide. The complete topic guide can be found in Appendix B: Topic List.

For this study, a total of 10 (N =10) meaning-making interviews were conducted that in total lasted between 45 to 60 minutes. Before conducting the first interview, a trial round was held with two people in order to test the experience and the questions. Before the interviews were conducted, all participants were asked to review and sign a consent form. When the interviews were conducted, consent to the interview was again verbally requested and promised that all personal information would be anonymised.

Even though the experiment was executed in the form of dyads, the interviews were conducted individually so the participants would not influence each other's opinions. The interviews were held just before and right after the experience at the *Leids Virtuorium* in a quiet, separate room in order to ensure for proper audio recording. The interviews were held in random order, as the participants got to choose who would be interviewed first.

The interview was conducted in two parts: the first part took place before the experience, and the second part took place after the experience. The first part of the interview lasted about 15 minutes. The interview started with a brief explanation of the experience and general questions about previous experiences to put the interviewee at ease. Questions related to the participant's social space were asked to determine the interpersonal relationship with their fellow participant.

The second part of the interview was conducted right after the experiment. The person that needed to wait to be interviewed was asked to write down a personal first reaction regarding the experience. The interviews consisted of four parts: the first part was arranged in such a way as to allow the participant to get back to reality. The second and the third part of the interview were devoted to social presence, sociability and social space. The last part was focused on understanding the entire experience and probing about any possible missing information. An audio record of all interviews was created. The interviews were conducted from 20-04-2022 to 15-05-2022.

The participants' names have been changed to pseudonyms after the interviews were conducted. The list of the participants with additional information can be found in Appendix A: Participants List. The audio-recorded interviews were transcribed verbatim using the translation

software Amberscript⁵ and resulted in 71 pages of transcripts. After Amberscript translated the interviews, the researcher double-checked the transcripts for any misinterpreted words and sentences.

3.2.2. Thematic analysis

This study's process of analysis was done through a thematic analysis. In a thematic analysis, data are restructured to create findings (Boeije, 2010). Thematic analysis is used to identify, analyse and describe patterns or themes within data (Braun & Clarke, 2006). This study uses Braun & Clarke's (2006) definition of qualitative research as "a method for identifying, analysing and reporting patterns (themes) within data while organising and describing data in rich detail. However, frequently it goes further than this and interprets various aspects of the research topic" (p.79). In addition, they also emphasise that although thematic analysis is open to interpretation, it is always important to position the analysis within a theoretical framework (Braun & Clarke, 2006, 2013). Even if the data is not a prevalent theme but is essential to answer how the interaction between the participants was perceived, it is theme-worthy (Boeije, 2010; Braun & Clarke, 2013).

There are different types of thematic analysis: deductive and inductive analysis. Deductive analysis is an analytical method that aims to test existing categories or theories (Goswami, 2011). The inductive analysis aims at deriving more general concepts through interpretation of data (Heit & Rotello, 2010). The starting point of this research is the theoretical concept and measurement for social interaction proposed by Kreijns et al. (2022). Nevertheless, there is also room for inductive interpretations. After all, a concept is only a specific framework, and the researcher is always expected to approach the data with an open-minded yet critical look (Braun & Clarke, 2013).

This study was conducted according to the six stages described by Braun and Clarke (2006), using the software Atlas.ti to organize the collected data. It cannot be stressed enough that carrying out a thematic analysis is not a step-by-step process, and it requires constant going back and forth between phases, data and theory. The phases as described by Braun and Clarke (2006) are the following: 1) familiarising yourself with the data; 2) generating initial codes; 3) searching for themes; 4) reviewing themes; 5) defining and naming themes; 6) producing the report. The conditions set by Braun and Clarke (2006) for the performance of thematic analysis are related to the requirements of Boeije (2010).

The phases described by Braun and Clarke were also applied in this study. For this study, this means that (1) the transcripts were read through several times, notes were taken and the data was subdivided into groups according to the primary research (2). Then (3) the codes were combined into possible themes and (4) approached several times as objectively as possible. Also (5) the themes were named and (6) reported. According to Boeije (2010), three main principles should be considered when performing thematic analysis: constant comparison, analytical induction and theoretical sensitivity.

⁵ <https://www.ammerscript.com/en/>

Constant comparison concerns the constant going back and forth in conducting research and analysing the data (Boeije, 2010). The most valid result is obtained by constantly going back and forth between interview data and the theoretical framework as proposed by Kreijns et al. (2022). Also, the data has been looked at with a constant critical eye in order to be able to explain and interpret deviating results.

While considering the principles mentioned above, thematic analysis involves coding the data in three steps: open coding, axial coding and selective coding (Boeije, 2010). Open coding refers to analysing and segmenting the data. Axial coding refers to the search for categories created by the open codes. The main purpose of axial coding is to distinguish between the predominant codes and the less important ones. No codes should have the same meaning; otherwise, they are merged. The last step of conducting thematic analysis is selective coding, which entails reflecting on the relationship between the dominant themes and finding possible central themes covering the sub-themes (Boeije, 2010).

These three steps for performing thematic analysis were performed several times and resulted in a final coding tree. The present study resulted in 194 open codes that were reduced to 15 axial codes. Together these codes are sub divided into 6 selective codes. The list of axial and selective codes can be found in Appendix C: Axial and Selective codes.

3.3. Recruitment process

In order to obtain a suitable sample, the purposive sampling method was applied. According to Polkinghorne (2005), purposive sampling means that participants are chosen from whom the researcher can learn about the experience. The researcher chooses a representative sample that meets the sampling criteria that have been established.

Several criteria were chosen to select research units. For social interaction to take place, at least two communicators are required. Therefore, it was determined that the experiment would be conducted in the form of dyads. According to Granovetter (1973), there are two types of relational ties: strong relational ties (e.g. friends, loved ones or family members) and weak relational ties (e.g. acquaintances or strangers). Falling back on the theoretical framework, it was determined that a positive social space would promote social interaction in an immersive environment (Johnson & Johnson, 2009; Kreijns et al., 2022). Therefore, another criteria was the existence of an interpersonal relationship in real life between the participants forming a dyad.

Since a positive social space will promote social interaction in the virtual environment, it was preferred to recruit dyads with strong relation ties. However, to analyse any possible differences in the influence of social space on how they perceive social interaction, people who signed up individually were also accepted to eventually match with another participant to provide diversity to the sample.

Another criterion for being suitable for this study was that the participants had to be between 18 and 35 years of age. A quantitative study by Hooper-Greenhill (1994) shows that the younger generation has become accustomed to using new technology more quickly, and that the older generation (aged 35 and over) finds this acclimatisation more difficult. In order to experience social interaction in an only 30 minutes lasting experiment, it is beneficial to adapt to the technology as quick as possible. Therefore, this study choose to focus on recruiting participants who would be most likely to get familiar with the technology easily. It was decided not to include minors in this study for ethical reasons.

Finally, a condition for participating in this research was that the participants were aware of virtual reality, but did not have any previous experience with immersive VR. This was decided mostly to test the technology. Previous experience may influence the perception of the haptic vest, controllers and goggles, the perception of the experiment in itself, which may ultimately affect answers given during the interview. It is worth mentioning that only three criteria are not many in the sense of purposive sampling. However, the openness of the criteria does suffice the research due to the explorative nature of the research.

In total, there were 14 responses to the open call: six were couples of potential participants categorised as having strong relational ties. Two potential participants signed up individually. Naturally, after their agreement, the two individuals formed the seventh pair. This couple was deliberately chosen to participate in the study to provide diversity in the sample. This particular couple was purposefully recruited to give more insights into how social space affects social interaction.

Due to unknown personal circumstances, two of the six dyads that had strong relational ties resigned from participating. Due to a tight schedule, rescheduling the interviews was impossible. This resulted in a final sample of five couples (i.e. ten participants). Four out of five couples were categorised as having strong relation ties; one couple was categorised as having weak relational ties.

A list of each interviewee's characteristics is presented in Appendix A: Participants List. The participants of this research were initially recruited by placing an open call at the café and cultural centre of the University of Amsterdam. Data on the average age of students in the Netherlands show that even the average age of a student in the Netherlands was set at 23,0 years old within a range of 18 to 35 years old (Central Bureau for Statistics, 2021). Since it was chosen to study people in between this age range demographic, the café of the University of Amsterdam was a suitable recruitment environment.

Lastly, since the experiment was about social interaction, and the participants were placed in a café-like setting that resembles a café in the physical world, it made sense to recruit potential participants in a social environment.

3.4. Operationalisation

Operationalisation is a process of establishing the measurement of a phenomenon that is not directly measurable but whose existence is inferred from other phenomena (Ambrosini, 2001) and thus refers to how concepts are made measurable. This study focuses on the users' experiences of social interaction in a mediated environment. Therefore, the experiences are linked to sociability, social presence, and social space as proposed by the social interaction model designed by Kreijns et al. (2022). Based on these concepts, the three sub-questions were also formulated.

It is worth noting that purposefully, the participants were not offered a definition of social interaction, immersion and presence in the interview questions to provide greater flexibility when answering and reflecting on questions about their subjective experience of (social) interaction. Other abstract concepts were translated into simplified terminological terms when formulating the interview questions.

3.5. Validity, reliability, and ethical matters

At all times and all stages, while conducting this research, it was a driving factor to conduct the research as rigorously as possible to ensure validity and reliability. Validity is the degree to which the results are valid and correspond to reality and reliabilty concerns the ability to replicate the research (Leung, 2015). In order to achieve validity of the study, the research design and measurement devices must be critically examined.

In order to achieve validity, one pilot experiment and two pilot interviews have been conducted in order to improve the topic guide. By implementing pilot rounds, a researcher develops interviewing skills and if she is testing whether the research measures what it is supposed to measure. This is essential for collecting accurate data through in-depth interviews (Hermanowicz, 2002). In addition, each phase of the research was carefully documented, by making any comments immediately after the experiment and interview, by writing down descriptions of participants, and by recording and transcribing interviews.

It is a requirement for a scientific study to be reliable (Gilbert, 2000). The reliability of research depends on the extent to which the same would be measured if the study were to be conducted again (Silverman, 2011). A number of actions have been taken to make this study as reliable as possible. First, the methods were applied consistently. The experiment took place in a controlled environment, where all five experiences were the same. In addition, all interviews were conducted in the same room immediately afterwards. The research process was also standardised. All participants received the same information prior to the experiment, and the same questions were asked during the interviews.

Not everyone did exactly the same during the experiment, since all participants were allowed to move freely in the immersive VR environment. However, due to the explorative nature of the

experiment, this does not invalidate the validity or reliability.

4. Findings and discussion

After the analysis process has been described to its fullest, this chapter will report the study's results. As this research aims to answer the question "How do users experience social interaction in an immersive VR environment?", it is important to deconstruct it to its three core themes. In doing so, the results are structured around the three sub-questions extrapolated from Kreijns et al. (2022) conceptual work regarding mediated social interaction. After discussing the findings related to the three sub-questions, a final section will elaborate on the personal experience of the participants. The chapter's sections are *social presence*, *sociability* *social space* and *personal experience*.

4.1. Social presence

The first section of the results chapter presents the results of the analysis connected to the question "How do users experience social presence in an immersive VR environment?". The analysis of the interviews resulted in two common themes identified that demonstrated how users perceive the realness of the other participant – *non-identification* and *identification*. These themes encompassed different ways in which the participants experienced the "realness" of the other in an immersive VR environment. Once again, social presence is defined as: "perceiving the other as 'real'" (Kreijns et al., 2022).

The analysis shows that even though verbal (e.g. voice) and non-verbal (e.g. gestural and spatial behaviour, gaze) cues, together with the characteristic height, did contribute to experiencing some aspects of social presence, the animated representation overruled perceiving the other person as 'real'. Below is a thorough description of the two discovered themes.

4.1.1. Identification

The findings suggest that some aspects of social presence were experienced due to verbal and non-verbal cues, together with *height difference*. The verbal and non-verbal cues contributing to the 'realness' of the other person are: *voice*, *gaze* and *spatial and gestural behaviour*. Below, all these themes will be elaborated on further.

The most prominent characteristic of the immersive environment that contributed to experiencing identification was the *height difference* between the avatars, corresponding with the actual height difference between the participants. Especially all participants with a significant height difference (4) mentioned that the accuracy of the avatars' size caused them to identify the other participant.

Fleur, for example, explained that even although the avatar did not resemble the other participant in real life, she identified the other avatar as Merel because of the height difference:

Yes, well, the avatars were completely different from the two of us. But of course, it was really, it was really, that she is a bit taller than I am and that then,

I don't know, I felt that very quickly, okay, so you see the difference between our figures and that corresponds to reality. (Fleur, female)

Merel was also very positive about the height difference and stated it was one of the main contributors to recognising Fleur:

I really saw myself and Fleur, also because she was smaller. I really liked that, because that just made it feel more like her and then for example when she was at the pool table that she really stood in front of me, that I just felt myself moving backwards, while she also didn't quite touch me, but that made it feel more like she was very close to me. (Merel, female)

Through the positional tracking offered by immersive VR, the height difference between real-life participants was translated well into the avatars. Although the animated characters did not resemble a representation of a human being at all, let alone was a unique representation of the participants themselves, the difference in height ensured that there was some recognition. Although the difference in length is not a nonverbal cue but a characteristic trait that is transferred, it is not surprising that it contributes to recognising the other. The fact that the participants know each other in real life contributes to assigning characteristics such as the height of an avatar to the resemblance with the other person. Therefore, the social space influences the sense of social presence or 'realness' and is in line with the work proposed by Kreins et al. (2022).

Spatial and gestural behaviour was acknowledged as contributing to the feeling of identification. Participants addressed the fact that they recognised the way the other participant was moving through the virtual reality environment, which contributed to recognising the other. Anita, for example, explained the following:

Yes, because of course I know her, [...] and she is a bit clumsy. So, I see her, say, jumping around a bit and clumsily not being able to get off a bench, just like she always does. (Anita, female)

This quote illustrates that the participant recognises the way Priscilla is moving through the immersive VR environment and resembles the way she moves in real life. This is underlined by Priscilla, who described the way Anita moved as "Once in a while she made a kind of movement, I thought, oh that's just like Anita doing yoga or something, you know." (Priscilla, female). Other participants also mentioned the gestural movement of the other as contributing to recognising someone's personality:

I remember saying at one point: I can just see from the way you move that it's you, you know, the way she plays, yes, just how she stands by that table and tries to grab things and move. And when she's playing a game, then all that body goes with it. So then she stands there and then she jumps and then you see the whole avatar going in all directions when she throws a ball, so that's funny, I recognised that immediately. That you immediately recognise someone's personality in the real world. (Hugo, male)

The fact he compares her spatial movements to real life, concludes that her gestural motions led to perceiving some realness by recognising her physical gestural behaviour, which contributed to the identification of the other participant. Even if the participant first claimed not to experience recognition of the other person because of the looks of the animated avatar, it was the gestural behaviour that was brought up:

It is also of course I think, because the face does not really look the same... But, of course you hear each other, and you know, it's the other person. And the way he is doing his thing... And that feels, yes, maybe it was him. Yes, a bit. But not quite, it is just that someone does not look the same. But you do the same. Do you get it? (Wendy, female)

As Wendy explained, even though she did not really recognise the other participant, the way he acted did make her recognise him. It must be noted that this illustrates recognition of the other, but still does not justify the feeling of the other as being 'real'. The exemplary quote above also explains, that being able to *hear the other person his or her voice* also contributes to identifying the other person: "Because you can hear the voice of the other person, yes. That is how I recognised Priscilla" (Anita, female). Lastly, a few participants (2) mentioned recognising someone's *eye gaze* when they were staring into each other's eyes:

When we really stood against each other and I see her looking at me like that and it feels very real, exactly. That was indeed a bit like I am looking at Fleur's avatar, but it is Fleur and it is not Fleur. Yeah, but so that and because her eyes really moved." (Merel, female).

Merel describes here that even though she was wearing a Head Mounted Display (HMD) and not physically together with Fleur, she still felt like she was really looking into Merel her eyes and it felt as if it was 'real'. By literally using the word real it concludes the other participant felt real because of gaze. Hugo added the following:

I did notice that Wendy's movements could be a bit the same and that at one point she really looked at me with those puppy dog eyes, as she always looks at me when she wants something from me. So that makes her really real. (Hugo, male)

Quotes mentioned above illustrate that the participants recognised each another. It is the verbal (someone's voice) and non-verbal (gaze, gestures and voice) cues that led to recognition. This is in line with Hinde and Hinde (1972). They state that verbal and non-verbal cues contribute to the recognition of the other person and are therefore beneficial for social interaction. Short et al. (1976) take it one step further and conclude that verbal and non-verbal cues contribute to social presence. The exemplary quotes above show that the social cues indeed influence how the realness of the other participant is perceived in a positive way. However, these social cues may contribute to some form of realness by recognizing the other participant, it does not correspond to Kreijns et al. (2022) their exact definition, which says that social presence is only sufficient when the person is experienced as "real".

4.1.2. Non-identification

The second sub-theme derived from the analysis regarding the first research question is non-identification. Non-identification refers to the simple non-identification of a certain subjectivity. The visual representation as avatars instead of more human-like (or personalised) characters was often mentioned as reason to explain why the other participant was not perceived as "real" during the experiment. In total, more than half interviewees (7) mentioned the representation of the other as animated as "distracting" (Jakob, male), "weird" (Sara, female) or "outdated" (Wendy, female). When talking about the other participant, the interviewees often referred to them as the other avatar or ghost, implying the person was not perceived as real. The participants did experience the presence of another being, but not necessarily the other participant specifically. For example, when asked to elaborate on that, Sara replied: "Well, because... His avatar is not really a human. It should be more human-like. Right now, it is more like an, ehm, random cartoon figure." (Sara, female).

Giving the fact that he did not look 'human' as a reason for not recognising the other participant implies the animation was constraining the experience of the other as real. Wendy (female) said that ".... Well, I just find it very important to see someone's face" when asked why she felt like she did not recognise the other participant. Even though she was looking at him during the interaction, she did not experience feelings of recognition of the other participant because of the animated representation. Both examples show that the animated representation of the other participant constrained their perception that the other person was real.

Anita described more or less the same phenomenon, when describing how she experienced looking into the mirror together with the other participant:

When we put on the mirror we saw each other and then you see the movements you are doing. And then I really noticed that oh, yes, wow, that it was accurate for VR and that you really see that I do too, because you see Priscilla and I see Priscilla moving. But then you don't know if Priscilla really moves, say, in her VR clothing and so on. And in the mirror you really see, because everything reflects and you see that your arm can move, that you can do this and that you, yes, also that you can do your arms up and that you, yes, that all that is fed back and then I noticed that I thought oh, yes... But it is of course still anonymous, but Priscilla is still acting so there are actions that she performs... that she really does. So that part does not make it less anonymous, but it does make it more human or something like that, but that's a strange combination. (Anita, female)

She explained that even though the movements made the avatar seem more real, it still felt as if she was with a stranger in the virtual environment. Using the term anonymous to describe how she feels towards Priscilla can be interpreted as not identifying the other. This is in line with research stating that the use of avatars may influence how social interaction is perceived (Maloney et al., 2020; Manninen & Kujanpää, 2007). The animated representation creates a particular distance between two communicators, as it is not a representation of how someone looks in real life. In the case of a digital twin (Jones et al., 2020), it could be that animation would be less of a barrier, since the animation is then an exact digital replica of the other person. However, that is not the case in this particular research.

4.1.3. Discussion social presence

According to Walther's (1993) impression formation and impression management theory people adapt to the medium's restrictions. Even when they are not able to use all non-verbal cues in Computer Mediated Communication (CMC), they will look for clues in the language they can use. This is in line with the findings of this research regarding how people perceive social presence. Even though animation restricted the users from the ultimate social presence, they adapted by recognising other features of the other participant by looking for non-verbal cues.

The two sections above illustrate that social presence (the "realness" of the other) was received differently. In particular, the representation of the other as an animated avatar got in the way of experiencing social presence. Maloney et al. (2020) previously concluded that animated representation is the biggest difference with face-to-face communication. Manninen and Kujanpää

(2007) state that it is possibly the biggest sticking point in mediated communication via immersive VR.

The most contributing to the experience of identification were height difference and spatial and gestural behaviours. These gestures are afforded by positional tracking of immersive VR (Desai et al., 2014) and resemble real-life movement. This is a unique immersive VR feature and contributes to the realness of the other participant.

Concluding, due to characteristics such as height difference, and verbal and non-verbal cues, some aspects of the realness of the other person are perceived due to recognition. However, due to the animated representation through avatars, the participants did not experience complete “realness” of the other person. Therefore, the social presence as proposed by Kreins et al. (2022) is not fulfilled, and the participants do not perceive each other as entirely “real”. A digital twin (Jones et al., 2020) could possibly change this.

4.2. Sociability

The next section dealt with the first sub-question, which concerned the “realness” of the other communicator. This section presents the results of the entire second sub-question:

SQ2: How do users experience sociability (the capacity of immersive VR to 1) allow for the expression of social presence and 2) the emergence of a social space) in an immersive VR environment?

This is a lengthy question that should be split in two. The first part of the question concerns the capacity of immersive VR to convey social presence. As noted earlier, social presence implies the “realness” of the other user (Kreins et al., 2022). The first part of the question would therefore be:

SQ2.1: How do users perceive the capacity of immersive VR to allow for 1) the expression of “realness” of the other user?

This question is already answered in the first sub-section of the results. The users perceive some ‘realness’ of the other user due to characteristics and the verbal and non-verbal cues that they are able to send and receive. However, the animated representation of avatars was constraining perceiving the other as “real”. The physical medium attributes of immersive VR therefore contribute to some extent to presence.

Presenting it this way are the height of the other person and the verbal and non-verbal cues affordances for social presence. Just as a coffee mug affords drinking from it, and my iPhone affords to check Whatsapp messages (Ingold, 2000), the non-verbal cues afford to recognise the other person as ‘real’, at least to some extent. Just to clarify once more, Priscilla mentioned recognising Anita as

‘real’ because of her gestural behaviour: “Once in a while she made a kind of movement, I thought, oh that’s just like Anita doing yoga or something, you know” (Priscilla, female). Just as Hugo recalled Wendy her gaze as her being presented as real:

I did notice that Wendy’s movements could be a bit the same and that at one point she really looked at me with those puppy dog eyes, as she always looks at me when she wants something from me. So that makes her really real. (Hugo, male).

Both exemplary quotes are also mentioned in the social presence chapter, but in order to answer the second SQ2.1, and give a proper illustration of how to interpret verbal and non-verbal cues as social presence affordances, they are addressed once more.

The second part of the second sub-question is:

SQ2.2: How do users experience the capacity of immersive VR to allow for the emergence of a social space?

As it turns out, the users perceived the capacity of immersive VR to allow for social space positively due to social affordances. This is in line with Kreijns et al. (2004; 2022) research, who state that social affordances determine sociability. As previously elaborated on, social affordances are possibilities for social interaction offered by the environment (Ingold, 2000; Kreijns et al., 2022). For example, the sad face of a friend invites for offering comfort, and a person waving at someone invites for conversation.

Just as the above examples invite for social interaction, do the games in the immersive VR also offer the opportunity for social interaction. For example, when Priscilla was asked to give a brief explanation of her overall experience, she said the following:

On the other hand, there is real experience that you share with someone. So that also feels very real actually, because you, we did it together, we communicated with each other, we played a game. Therefore it was definitely that we did something real with the two of us. (Priscilla, female)

Wendy (female) agreed, saying that the games made her feel together in the immersive VR: “I liked the fact that you could really play a game with each other, that you can interact with each other.” The quotes above illustrates that the games in the virtual environment did invite interaction. Although the experiment was explorative and unstructured for most of the experience, all participants (N = 10)

ended up playing a game. This also illustrates that games in the immersive VR environment afford for social interaction.

Concluding, Kreijns et al. (2022) stated that one of the pillars of social interaction is sociability: the attributes of the medium. The medium attributes are on the one hand the physical attributes of the medium and the ability to transfer verbal and non verbal cues through these physical attributes. In line with Walther (1993) these social cues afford social presence. On the other hand, the medium attributes are the social affordances immersive VR offers, which afford social interaction in the virtual environment (Ingold, 2000; Kreijns et al., 2004; 2022).

4.3. Social space

This last section, according to the deductive scheme, will present the results of the analysis connected to the concept of social space. To answer the third sub-question, “How does the social space of users influence social presence in an immersive VR environment?” it is first essential to confine the articulation of ‘social space’ to specific confinements. Social Space is defined as:

“the interpersonal and emotional connections between group members. The network of interpersonal relationships is embedded in group structures of norms and values, rules and roles and beliefs and ideals. A sound social space is manifested by a sense of community, mutual trust, social identity, and group cohesion. As such, social space can be seen as a group attribute.” (Kreijns et al., 2022).

Because social space is such a broad concept, the question is also very broad and exploratory. The aim was to be able to identify with an open mind, any differences in group structures, interpersonal relationships and character traits in perceiving social presence in an immersive VR environment.

A few observations were made regarding group structures, rules and roles, such as gender differences. As it turns out, gender plays a part in perceiving social interaction in the immersive VR environment. Jakob addressed that because he did not know Sara that well, it was uncomfortable to give her a hug in the immersive VR environment, mainly because of the sensors in front of the vest: “Well, yes, it’s just here [...] and she did it and I’m a man, but she is a woman, so... yeah, it is weird if I approach her and then just touch the vest...” (Jakob, male).

Sara herself did not seem to bother during the experience or during the interview afterwards, however Jakob’s response shows the sensory affordance of touch determined the interaction. Even though Jakob and Sara were the couple categorized as weak relational ties, it is more the difference in gender that is making the interaction uncomfortable.

A few other female participants (3) also mentioned the electrodes in front of the vest and that they were not perceived as an addition to the experience. Merel (female) for example, said the following: “I can imagine that with this vest, having interaction with a stranger would be

uncomfortable". This suggests that haptic technology design does not take into account gender differences (yet), and therefore is constraining social interaction in an immersive VR environment. It also suggests a possible gender divide in the ability to be fully present in the virtual environment due to the affordances of the technology.

As described in the theoretical framework, the different interpersonal ties between persons can be categorised into strong relational ties and weak relational ties (Granovetter, 1973). By means of providing diversity to the sample, one couple (dyad 3) was made out of two participants with weak relational ties. As stated by Kreijns et al. (2022), a sound social space should positively influence the social interaction.

Indeed, the results present that dyad 3 mostly talked about their own personal experiences and had almost no comments on how they perceived the other participant. When asked if they felt like they were really there together in the virtual environment, Sara replied: "I had the feeling of someone's presence, not so much him specifically" (Sara, female). This quote implies she did not perceive Jakob as "real". Even though it is only one participant categorized as weak relational ties, this could be interpreted as if it supports the argument of Kreijns et al. (2022) that a sound social space promotes social presence.

However, as it turned out, social presence is also perceived differently within couples. For instance, although Hugo felt completely present and really felt like he was there "with his girl", Wendy (his girl) did not have that feeling at all. Her answer to the question to what extent Hugo felt like actually Hugo, was resolute: "Well, not in any way. In the end, he still looked like a weird little figure" (Wendy, 23, female).

The above examples show that having strong relational ties does not secure a positive experience of social presence. The analysis also shows that presence is perceived differently among individuals: when one person is positive about the social presence, that does not automatically mean it is perceived just as positive as the other is perceiving it. Maria (female) for example experienced social presence without effort, but the other participant Madelief did not:

Yes, I think so, because I think it was easier for me to use the controllers than it was for Madelief, for example, and I think in generally it is also for older people, not that I am saying she is, but because younger people are just more used to having a *Wii* controller or a *PlayStation* controller in their hands. And then you understand how you walk and how the buttons work faster than if you're an older person, that never sat behind a playstation and then get this in your hands. And if you understand the technology, then you can start to communicate. But when you do not know how to use them, it is difficult.... (Maria, female)

The above quote states that Maria was aware that certain characteristics also contributed to social interaction such as age, as she mentioned, but of course also other personal factors such as experience. Because the analysis shows that social interaction is received differently by each individual within the experiment, it implies that there might be another relevant factors at play when drawing conclusions, namely personality. This is in line with Weidlich et al. (2021), who argue that it may be individual differences that determine perceptions of social presence. The results of their research show that certain character traits are more susceptible to perceptions of social presence (Weidlich et al., 2021)

There were no other remarkable observations about the social space affecting the social presence. This might be due to the homogeneity of the group, but another big part is because of the lack of ability of the technology to afford immersion. This notion will be addressed in the next section of the results chapter.

4.4. Personal experience

By trying to answer the sub-questions, two other themes emerged from the analysis regarding the personal experience: *presence* and *act of immersion*. Since none of the participants had previously experienced being in an immersive VR environment, most of them naturally shared their thoughts and feelings on how the immersive VR environment was perceived.

Due to the affordances of the immersive VR environment itself and the participants' personal and social characteristics, the feeling of presence was present. Ironically, the physical immersive technologies of the immersive VR systems did not allow for immersion to take place. This additional section on the users' overall experience of immersive VR feels important for the future implementation of immersive VR. Below, both themes will be discussed and illustrated with exemplary quotes.

4.4.1. Presence

Building on Kreins et al. (2022) definition of social presence (the “realness” of the other participant), *presence* is defined as the “realness” of the overall experience. This is in line with Walther and Parks (2002) and Witmer and Singer (1998), who define presence as the subjective experience of being present in a virtual environment. The analysis resulted in five sub-themes regarding presence: *resemblance with the real world*, *interaction with the virtual world*, *natural interaction with the other participant* and *embodiment illusion*.

Most participants experienced presence in one way or the other (9). The first sub-theme is *resemblance with the real world*. As stated in the description of the set-up of the experiment (§ 3.1), the participants were placed in a room that resembled a café setting in order to achieve as much resemblance to a real-life social setting as possible. The results of the analysis confirm that the

resemblance of the virtual environment with the physical world has a positive effect on presence. For example, one of the participants answered slightly flabbergasted to the question if he could elaborate on what he thought of the virtual environment: “I really, no, that was very yes... I don’t know, I didn’t expect... that it would be so realistic” (Jakob, male, 24). This is confirmed by Hugo when he elaborates on what was ‘real’ about the experience:

You can really do your own thing or something. When it was Wendy’s turn [during playing a game of pool], I just went to the other table. Just to look at the art on the wall, or something like that. And then you’re just really... there. [...] Just as I would watch the posters in a bar when I have nothing to do. (Hugo, male)

Both quotes illustrate that the resemblance of the environment and its objects have a positive effect on presence. The fact there are posters to watch, makes him feel comfortable and present in the virtual reality environment. This is a pretty straightforward outcome, but since it came up in almost half of the research units (4), it is worth mentioning.

The second sub-category derived from the analysis is *the interaction with the immersive VR environment*. At some point during the experience, Sara and Jakob were just wandering around the virtual environment. Jakob, who works behind a bar, naturally stepped behind the bar and tried pouring a beer with success. He then started experimenting with what else he could do in the virtual environment and found out he could also perform actions like filling a glass or throwing bottles on the floor with one arm whip.

Sara remembered seeing him cleaning up after throwing all the glass on the ground: “At some point I even saw Jakob cleaning up the mess he made” (Sara, female). Jakob indeed remembered the same event himself during his interview, stating that: “For me, it was really when I had a drink in my hand. Then I thought, wow. Really just that I could just do that, that was really the moment I thought it was real” (Jakob, male). These examples illustrate perfectly that the interaction with the virtual environment is beneficial for experiencing the environment as “real”. The fact that Jakob started cleaning up the mess he made implies his natural response was to behave like he would in a physical social setting. When asked why he cleaned up the mess he made, he responded: “well, I would also clean up if I break something in my own bar, would I not?”.

The interaction with the virtual reality environment was not only bound to objects. Another prompting sub-theme regarding presence is *natural interaction with the other participant in the virtual environment*. Sara’s answer is a prompting example of interaction between participants contributing to presence: “Yes, yes, the interaction also makes you feel present. Present in that space, you know what I mean? I mean the communication, and that you can communicate with others...” (Sara, female).

Since the virtual environment was designed in the social setting of a pub, it was also possible to play games such as playing pool or “drinking games” such as beer pong (e.g. throwing a ping pong ball in the cup of the other participant). The natural interaction that took place by playing a game of pool or other games enhanced the experience of presence. Merel (25, female) explained for example

Everything feels very natural. You can play games there, you can pick things up, it really feels a bit like a playground, yes, just, and then time flies by because at one point, I caught myself trying to lean on that cue, because of course in the I in real life, you do that too. [...] I secretly feel like I have just played a game of pool!

Merel was not the only one experiencing a high degree of presence when she was playing games. Another participant recalled playing beer pong when her phone accidentally rang during the experiment. She wanted to take her phone out of her pocket and naturally placed the controllers on the table. Of course, the table was in the virtual environment and not in front of her in the physical environment, so the controllers fell but were saved by the safety wristbands. By trying to place the controllers on the table, she shows the boundaries between the physical and virtual environments.

These examples illustrate that natural interaction contributes to the “realness” of the experience. More specifically, the analysis indicates that social interaction enhances presence. Social interaction is stimulated by the social affordances in the virtual reality environment. Just as a coffee machine invites for a conversation with a colleague, the games in a virtual environment afford social interaction, which in turn contributes to presence. It can therefore be concluded that just as social affordances determine sociability (Kreijns et al., 2004; 2022), they also contribute to the overall “realness” of the experience.

Embodiment illusion turns out to be beneficial for presence. Maria (female), compared the immersive VR experience with previous virtual reality experiences:

This experience today feels more real, because you can walk here yourself, feel things yourself, play games yourself. It just feels more real. Actually, the other [experiences] are as if you just watch a kind of 3D film. And this is real: you are in it and you move how you want to move.” (Maria, female, 21)

Using words like “real” to compare the experience to previous 3D virtual reality experiences without positional tracking illustrates that positional tracking contributes to presence. Positional tracking creates embodiment illusion, a term that refers to the feeling as if your body embodies the avatar (Gonzalez-Franco & Peck, 2018).

The participant's response illustrates that because she felt like she could move freely through the virtual space, the experience felt real. This is confirmed by another participant referring to the fact she could step aside, contributing to the realness of the experience: "You don't have any foot sensors, but still, if you take a step or if you notice that your upper body moves a little, then you take that step with it. So it feels very natural" (Merel, female). All these examples illustrate how positional tracking contributed to the feeling of presence through embodiment illusion. All the participants felt as if they were embodying the avatar because of positional tracking. Positional tracking creates the illusion of inhabiting another body.

4.4.2. Immersion

The immersive technologies of the immersive VR systems did not allow for immersion to take place. The previous sub-section dealt with the theme presence and showed through examples that presence was present among the participants in the immersive VR environment. This sub-section argues that immersion, as a technological attribute, was absent. Immersion refers to the ability of a Virtual Reality system to make someone feel like they are somewhere else (Oh et al., 2018).

In other words, it refers to the sensory information that gives the impression of being in another place (Slater & Wilbur, 1997). Immersion concerns Virtual Reality devices and how well they can transfer sensorial information (Skalski et al., 2009; Cummings & Bailenson, 2016; Oh et al., 2018). Unlike presence, which is about the psychological experience of being in a virtual environment (Oh et al., 2018).

First, the analysis concludes that the technology failed to generate immersion. It should be noted that perfectly immersive technology should not be noticeable and thus should not come up much in the interview if not prompted. However, all interviews mentioned the technology by calling out sensorial information (i.e., audio/visual information or haptic feedback). Below, the themes of *haptic feedback*, *visual information* and *audio information* will be discussed.

Most participants mentioned the *haptic feedback*. The participants either experienced too much or too little haptic feedback. This results in the sub-theme of haptic feedback as a barrier to the act of immersion. A female respondent, for example, explained: "You feel that vest in certain places, but not on your arm so you don't feel any vibration there. It is limited by the physical materials, but it was not an uncomfortable experience" (Priscilla, female).

According to this respondent, the physical materials were constraining immersion. More specifically, she described experiencing the haptic feedback as unequally divided over her body. Again, the fact that she mentioned the limitations of immersive VR technology in the first place illustrates how the technology is withholding immersion and constraining presence. Other participants (2) mentioned the vibrations of the haptic vest being distracting. For example, Sara compared the vibrations of the haptic vest with "a too hard massaging chair but then on your body", and Jakob referred to the haptic vest as giving "unsubtle vibrations".

Other participants recalled missing the sense of touch when trying to interact with the other participant in the environment: “At some point, we tried to do this game of clapping our hand together, but … [Your hand] goes through the hand of the other, and that doesn’t give you a vibration” (Madelief, female).

Again, the fact that she mentioned the way of interacting with the other person and the environment demonstrates that the lack of haptic feedback may not contribute to the act of immersion. The quote implies that the participant did expect to feel the resistance of the hand of the other participant, at a moment when she was absorbed in the environment and wanted to play a game with the other participant. However, because of the lack of haptic touch, she was drawn back from the virtual environment.

This is confirmed by Wendy, who also stated that “especially the touch of hands, would have made it more realistic”. Also, Merel, who said that she almost gasped at the ball because she wanted to feel it, but she “did not get a response”. It is worth mentioning that all the examples above refer to the haptic feedback as vibrations instead of touch, which also implies the haptic feedback was not received as real touch and therefore constraining presence.

Another sensorial information that was constraining the technology from immersion was the *visual information*. This can be concluded from the first exemplary quote, where Priscilla stated “.... [the goggles] are not lenses yet” (Priscilla, female). This implies that she sees potential in the technology; however, for now, it is constraining from immersion. Another participant Wendy compared the image quality with “a computer game from 2012”. Again, the fact that the visual information was mentioned illustrates that the visual information was constraining the act of immersion. The term “VR glasses” and “goggles” together were mentioned 59 times in the dataset.

Another element of visual information constraining immersion taking place was the *animated representation*. To avoid nauseousness, every time participants moved, they first saw the avatar moving before the point of view changed. Jakob (male) explained he would rather not see himself since it was taking away the realness of the experience: “And then you see your own avatar. And I would rather not see myself. Then it’s more real.” (Jakob, male)

Another participant also mentioned that even though the social interaction made her feel present, animation was the major drawback from immersion when asked if she really felt like she was there:

Well... It is all very obviously animated. You’re not even something that really resembles a human being, you know, so in that sense of course it wasn’t real at all. On the other hand, there is real experience that you share with someone. So that also feels very real actually, because you, we did it together, we communicated with each other, we played a game. In that VR from me was definitely that we did something real with the two of us.” (Priscilla, female)

The exemplary quote above shows it was the animated representation that was constraining the feeling of recognition. However, the social affordances of the environment did create some (social) presence.

Lastly, the audio information provided by the virtual reality technology was also not contributing to the immersion by the technologies. Even though it was received way less negatively compared to the visual information and haptic feedback, the fact that it was mentioned a couple of times during the interviews illustrates that there was no complete immersion. The audio was mentioned in 8 out of the 10 research units, mostly in the sense that the participants could imagine that whenever the quality of the sound would increase, it would have a positive effect on presence. Hugo mentioned for example the following:

No I was not completely [there], and I think that's mainly the headset thing. I think that if you have one of those big ones, and you really have noise cancelling around the ears, then you would really... Then the outside world really disappears completely. (Jakob, male)

In short, the immersive VR was not able to immerse. Immersion has to do with the technological affordances of the medium, in order to afford presence. It is the (dis)abilities of the haptic feedback, audio information and visual information that is constraining the feeling of being in a completely another environment. Going back to the first theme, it was the verbal and non-verbal cues that helped with recognizing the other as 'real'. This research shows that these social cues are contributing whenever it is linked to an emotional connection that brings feelings of resemblance. Whenever it is just pure plain sensorial information, the immersive technology is rather constraining. This is in line with Kreijns et al. (2022), stating that the social space influences social interaction by influencing social presence.

4.4.3. Discussion of presence and the act of immersion

In the previous section, the themes *presence* and *immersion* are discussed. Once again, Mel Slater (2003) distinguishes the two concepts as: "Immersion refers to the objective sensory fidelity the system provides. Presence refers to the users subjective psychological response to a VR system." (p. 2)

However, when asked about the whole experience, the words "real" and "absorbed" were often used, suggesting that the subjective experience feels like presence. It is because of the naturalness of the interaction made possible through affordances, embodiment, interaction with the environment and resemblance with the real world that the participants did feel present in the immersive VR experience.

Because the features of immersive VR are real, together with the social affordances, the embodiment, and natural interaction presence is experienced even though the participants are not

immersed. The fact that posters are recognised as posters, for example, outweighs the animated display of the posters. Just as recognition of the other through height outweighs the animated representation of a loved one.

This is a sound example of how social space - the beliefs, values, and group structures - influence social presence and therefore social interaction. This is in line with Kreijns et al., (2022) who state the three concepts are related and cannot work separately.

For example, when Hugo walks over to look at the paintings on the wall while playing a game of pool, this is narrated as if he were describing an interaction with Wendy in real life. By recognising posters as concept posters (meaning-making), along with the social interaction of playing a game of pool, the experience is real even though there is no vivid similarity to the real world. Thus, in an immersive VR environment, someone can perceive the experience as real (presence), even though the technology did not afford immersion.

The analysis showed that immersion was also experienced in a more positive sense of presence whenever there was a high sense of presence. Hugo for example was very impressed and enthusiastic about the whole experience. Therefore, he was also the least critical of sensorial information. The analysis proposes that when experiencing a high degree of presence, the (lack of) immersive technologies matters less.

Once more, the technology would not be noticeable in a perfectly immersive environment. However, there were quite a few snags with the technology. The vest and glasses were often described as uncomfortable and distracting, and some components did not work initially. The research concludes that most participants felt present in the virtual environment, even though the immersive technologies did not perceive immersion.

The two concepts are related, and immersive technologies are important in order to feel present. Immersion can achieve potentially perceive optimal (social) presence as defined by Kreins et al. (2022). It would make sense to conclude that if the representation of the virtual environment is optimal, but the technology is not working properly, it is impossible to feel there, so presence is ruined. However, the analysis shows that when the participants are really engaged by interacting and performing social actions together, they feel like really being there. A high degree of presence was experienced most through social interactions made possible by social affordances.

5. Conclusion

This master's thesis examined social interaction in a 3D immersive VR environment. By placing 10 participants in an immersive VR environment while observing them and conducting interviews afterwards, social interaction and the interaction with the environment were examined. The research consisted of five experiments in the form of dyads and ten individual interviews. By observing and analysing the interviews, the answers to the sub-questions can be drawn, resulting in an answer to the research question: "How do users experience social interaction in an immersive VR environment?"

5.1. Answering the three sub-questions

immersive VR has emerged as a new medium for social interaction, wherein verbal and non-verbal cues can be transferred through positional tracking and other sensorial information beyond the audio-video such as haptic feedback can be perceived (Maloney & Freeman, 2020). How do these novel systems shape social interaction in a mediated environment? By trying to answer the research question, three sub-questions were derived from the theoretical framework. These research questions were formed around the concepts of *social presence*, *sociability* and *social space*. These concepts were derived from the social interaction model presented by Kreijns et al. (2022).

The first sub-question was "How do users perceive social presence in an immersive VR environment?". As it turns out, the participants experienced some aspects of 'realness' in terms of recognising the other person, due to the ability to transfer and recognise verbal and non-verbal cues such as gaze, gestural behaviour and voice within the virtual space. Other characteristics such as height also contributed to the other person being recognised by the other to some extent. This is in line with Walther (1993), who states people adapt to the medium's restrictions by looking for clues in the language they use and adapting their emotional and social expressions to the available language.

However, due to the animated representation of the other person, he or she is still not perceived as real as a person in real life. Only if the other person is perceived as realistic in real life, social presence is sound according to Kreijns et al. (2022). Therefore, even though some recognition took place, the realness as described by Kreijns et al. (2022), as derived from the term described by Short et al. (1976), was not completely achieved during the experiment.

The second sub-question was: "How do users experience sociability in an immersive VR environment?" Kreijns et al. (2022) stated that one of the pillars of social interaction is sociability: the attributes of the medium. The medium attributes are on the one hand the physical attributes of the medium and the ability to transfer verbal and non-verbal cues through these physical attributes. On the other hand, the medium attributes are the social affordances immersive VR offers (Weidlich et al., 2021; Kreijns, 2022).

The ability to play games together in an immersive VR environment can be seen as such a social affordance. Just as a coffee machine at a workplace serves as a place for employees to casually talk about easy topics, the pool table in the immersive VR environment serves as an enhancement for social interaction and the feeling of presence. This is in line with Kirschner and Kreijns (2005), who state social affordances determine sociability. It is because of these types of social affordances offered in the VR environment, together with the fact that non-verbal cues could be transferred, that some form of sociability was experienced.

The third sub-question was the following: "How does the users' social space influence social presence in an immersive VR environment?". As the results of the analysis show, gender plays a part in perceiving social interaction in an immersive VR environment. More specifically, it is possible the haptic vest affords a gender divide in the ability to be fully present. The couple with weak ties focused on the subjective experience itself instead of the interaction. When this relational space is sound, it offers the possibility to create social interaction. However, the results of the experiment show that a strong relational bond does not guarantee positive social interaction *per se*. Social interaction is perceived differently among each individual within the experiment.

This means that if one person is positive about the social interaction, that does not automatically mean that the other person perceives the social interaction just as positive. This implies there is another relevant factor to consider when drawing conclusions from the experiment conducted, which is personality. This is in line with Weidlich et al. (2021), who studied the potential of individual differences in predicting perceptions of social presence.

5.2. Presence and immersion

As concluded before, the difference in perceiving social presence might have to do with personality. However, it is also influenced by the lack of immersion afforded by immersive VR technologies. By trying to answer the sub-questions, two other themes were derived: *presence* and *immersion*. Immersion refers to the ability of the virtual reality system to trick someone into being somewhere else and has to do with sensorial information (Slater & Wilbur, 1997). Immersion is a medium attribute and technological quality (Slater, 2003; Oh et al., 2018). Presence is defined as how one really feels and engages with the virtual environment (Witmer & Singer, 1998), and has to do with subjective experiences, that make the experience itself real (Walther & Parks, 2002). As it turns out, the participants did experience presence, even though the immersive technologies did not provide immersion.

5.3. Research question

The answers to the sub-questions and the other relevant factors found all lead to the answer to the research question: "How do users experience social interaction in an immersive VR environment?"

The qualitative experiment illustrates that the current Virtual Reality techniques show many defects and should be improved in order for people to experience complete (social) presence. All participants mentioned flaws in the technology, indicating the Virtual Technology used was not able to provide immersion. It can be concluded that the current state of immersive VR technology does not allow for actual immersion.

Nevertheless, a sense of presence was created for most participants, mostly due to the ability to express themselves through verbal and non verbal cues and social affordances. Because of the recognition of the other participant due to these social cues and characteristics, (social) presence was experienced. This is in line with Kreijns et al. (2022), who state social space also influences social presence and thus social interaction.

This research shows that the current state of social interaction in 3D immersive VR environments falls short in terms of immersion and experiencing complete ‘realness’. The technological barriers limit immersion, but – depending on personality and gender - the first step towards sensing a shared reality is already there, namely presence. The answer to the research question is thus as follows:

Due to the current flawed state of immersive VR technology, there is no immersion present. Therefore, social presence as defined by Kreijns et al. (2022) is not perceived. However - depending on the personality and gender of the user - a first step in experiencing “real” social interaction within an immersive VR is there, since some form of sociability can be reached, especially when the social space of the users is sound.

5.4. Scientific and societal implications

This research contributes to existing research on mediated communication. There have been numerous studies on mediated communication in Computer-Mediated Communication (CMC) (Kreins et al., 2022). However, this branch of literature has so far focused on text-based audio-visual information communication only. This research adds to the scientific literature available since it investigates social interaction in a 3D immersive VR environment. This environment offers an extra dimension to mediated communication by being able to transmit verbal and nonverbal behaviour through positional tracking and provide additional sensory information such as tactile sense through haptic feedback.

This research also contributes to existing research by providing more insight into creating a sense of presence in a mediated environment. Even if immersion is not there, it is the social affordances, the interaction with the virtual environment, embodiment and social interaction that can still create the feeling of presence. This is a valuable insight for immersive VR creators.

Next to the contribution to the theoretical literature on mediated communication as well as social interaction in a 3D environment, this research has several societal implications. Web 3.0,

the metaverse and virtual reality as such can have an important impact on social interactions between people. It raises interesting questions about realness, immersion and the world as such.

However, it is important to measure the effect of 3D technologies on social interaction from the start, since this can contribute to developments in the immersive VR technologies by building on the experiences of users. Since the use of VR-technology can have a profound impact on many very different aspects of the physical world, such as education, culture, entertainment, work but also feelings as well as location, being able to assess the ‘realness’ of the social interactions in an Immersive Virtual Reality experience correctly is of the essence.

Apart from adding to the general understanding of social interaction in a 3D environment, this research confirms that the technology currently available still has many flaws. For now, being able to have a ‘real’ immersive experience is far from a reality. However, this research shows that it could be worthwhile for the developers of immersive VR technologies to consider building tools and social spaces in which people with a sound social context in the physical world can be together at a distance. It seems also useful to empower people to ‘build’ their own digital twin for use within the visual space presented. That way, the experience adds to the feeling of ‘realness’ and therefore to a feeling of genuine social interaction.

5.5. Limitations and future research

Initially, the applied qualitative research method is suitable for answering an exploratory research question by collecting insightful data from the user perspective about social interaction in an immersive VR environment and extracting comprehensive results. However, there are certain limitations that need to be addressed.

First, it can be concluded about qualitative research in general that it contributes to in-depth and comprehensive knowledge acquisition, but on the other hand, the generalisability of the findings is debatable. Especially when researching subjective experiences of broad and rather abstract concepts such as social interaction, which have multiple dimensions. Kreijns et al. (2022) social interaction model is comprehensive and abstract, which can make generalising the outcome difficult.

In addition, as mentioned earlier, Kreijns et al. (2022) social interaction model is focused on 2D computer-mediated communication, and this thesis has investigated mediated communication in 3D immersive VR because of the lack of proper up-to-date concepts and measurements regarding mediated social interaction. Although this does justify the choice to use this model, it can potentially limit the results of the research.

Third, immersive VR technologies are developing in a rapid pace. Therefore, it is important to point out that the outcome of this research is just a snapshot in the field of research on (Immersive) Virtual Reality. It is true that in any research field new findings are continuously made, but in the field of technology, the changes are so rapid that it is worth mentioning. Only during the process of

sculpting this thesis, new developments in the field of immersive VR have already been presented, such as Meta's Presence platform, for example (Bonifacic, 2021).

Other limitations are the sample size, the use of only one technological setup and only one environment. Due to lack of time, the sample size was rather small and turned out to be homogeneous. Further research should take into account a more diverse pool of people, ranging from more diversity in age and gender. Future research should also do multiple technological setups with different technology devices, in order to test the immersion in other setups.

Since immersive VR is a new way of social interaction in a mediated environment, it should be emphasized that research on this topic should continue to expand. Concluding, this research was conducted in a controlled environment whereas the users were conscious of participating in experimental research. Especially because the research aimed at a state of 'realness' or naturalness, this could have affected the results. Therefore, it should be noted that future research should be done in a more natural, less controlled environment.

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7. Appendix A: Participants List

#	Bond	Participant	Age	Sex	Date
1	Strong relational ties	Maria	21	Female	2022-04-20
		Madelief	25	Female	2022-04-20
2	Strong relational ties	Anita	23	Female	2022-04-22
		Priscilla	25	Female	2022-04-22
3	Weak relational ties	Jakob	24	Male	2022-05-01
		Sara	23	Female	2022-05-01
4	Strong relational ties	Merel	25	Female	2022-05-01
		Fleur	26	Female	2022-05-01
5	Strong relational ties	Hugo	23	Male	2022-05-13
		Wendy	23	Female	2022-05-13

8. Appendix B: Topic guide

Icebreaker

“What do you think of the environment?”

“Thanks for participating!”

Background

“Can you introduce yourself and what you are currently doing?”

“How old are you?”

“What is your level of education?”

Social Space

“What is the relationship between you two?”

“How well do you know each other? For how long have you known each other?”

“How often would you say you interact with each other on a daily/weekly/monthly basis?”

“How would you describe your relationship in real life? Has it changed?”

“How would you describe yourself and how would you describe the other?”

“What is the biggest difference between the two of you?”

“Can you describe a memory of one of your most favorite experiences together?”

“Can you name at least two similarities between the two of you?”

“Can you name at least two or more things you do not have in common at all? Which counts more?”

“How would you describe your position towards the other person and how does that make you interact with him or her differently than with others?”

Expectations

“Can you elaborate on your previous experience with Virtual Reality?”

“How would you describe your expectations of the overall experience?”

Icebreaker

“How was it?”

“How would you describe the experience?

“What was in your opinion the most remarkable during the VR experience?”

“How do you think he/she perceived the experience?”

Sociability

How did the sense of touch feel?	“How would you describe touching each other in the virtual environment?”
	“How would you describe the hug?”
	“How would you describe the experience of looking at each other in the mirror?”
	“How would you describe catching and throwing a ball?”
	“If you would describe moving through the environment how would you?”

Immersion

“How did the goggles and vest feel?

“How would you describe the quality of the image and can you give an example?”

“Was there a moment where you felt like you were completely absorbed in the environment during the experience? If not, why not?”

“Can you give an example of what was most distracting during the experience?”

“Can you think of a moment where you were not feeling like yourself?”

“Did you feel like you were swallowed by the surroundings?”

“How long do you think you were in there?”

Non verbal and verbal communication

How did communicating feel?	Can you describe one moment during the interaction where communication between the two of you was remarkable?”
	How would you say you were interacting between each other in terms of saying things?”
	How would you describe the volume?”
	If you think back to the facial expression/eye contact of [...], how was that?”
	How would you say the distance between the two of you was in the virtual environment?”
	What would you say about [...] his/her physical appearance in the virtual environment?”
	How would you describe the volume/pitch/I and hesitations in the virtual environment?”
	How would you describe your hand movements?”

Social presence

“How real did the experience feel for you? How/Why?”
What does realness entail?
“How would you describe the rooms in the virtual hotel and what do you remember most in terms of building and the affordances of the building?”
“Does being in the immersive VR environmentenvironment remind you of something the two of you did together recently? If so, what?”

“Would you say it is easier to feel present in the Vrchat with [...] than with others and why?”

“If you compare social vr to other social platforms, what do you prefer?”

“How long does it feel that your in there?”

Completion

“Are there any other things regarding the experience that you have not mentioned before?”

“Are there any other questions?”

“Thank you for cooperating and can I write down your contact details?”

9. Appendix C: Axial and Selective codes

Themes	Selective codes	Axial codes
Social Presence	Non-identification of the other person	Animation contributes to non-identification of the other person
	Identification of the other person as real	Gaze contributing to the identification of the other person
		Height difference contributing to the identification of the other person
		Sound of voice contributing to the identification of the other person
		Spatial and gestural behaviour contributing to the identification of the other person
Sociability	Social Affordances	Games as social affordances
	Technological Affordances	Verbal and non verbal cues as technological affordances
Social Space	Over all social interaction in immersive VR	Gender affects social interaction in immersive VR
		Personality affects social interaction in immersive VR
		Strong ties as neutral component for social interaction in immersive VR
Personal Experience	Act of immersion	Haptic feedback as a barrier for immersive technology
		Visual intermation as a barrier for immersive technology
		Audio information as a barrier for immersive technology
	Presence	Sound of voice as resemblance with the real world

		Interaction with the virtual environment contributing to presence
		Natural interaction in the virtual environment contributes to presence
		Embodiment illusion of virtual persona contributes to presence