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Abstract

Virtual reality (VR) technology is going through rapid development as the technology has finally reached levels enabling commercial applications for both consumers and businesses. In a business context these applications are often used to support the collaboration in the overall organization. This highlights the need to define VR as a communication medium and to evaluate its usability in the social context. Therefore, an exploratory research was conducted to demonstrate the current technology's ability to enable interpersonal interaction through the natural user interface, utilizing kinetic and proxemic cues. The communicational abilities were then reflected upon a conceptual VR Obeya, a lean manufactory solution enabling real-time, information-based collaboration and decision making in production system development.

The potential VR has as a communication medium is based on its ability to induce the experience of presence in the virtual space. This presence might enable plausibility illusion which enables the user to experience the events and interactions around them as if they would be real, and thus bearing similar impact. This illusion of plausibility relies on the experience to be credible and to meet expectations. It is suggested that inducing such an illusion could be done through verisimile design and the use of virtual metaphors. Verisimile means creating virtual events that are believable or "similar-to-the-real-thing" without recreating them in full fidelity. This is done by relating to the prior knowledge, or semantic encyclopedias, of the user, for example by transferring social norms into the virtual experience.

By enabling presence, the social influence of the interaction can be enhanced. Verisimile interaction could make VR communication have impact more on the levels of face-to-face communication. This improvement can be utilized in Obeya by creating a solution that enables the use of modern information systems and digital data without decreasing the capabilities for collaboration and social interaction. However, before such benefits can be realized, VR as a communication medium has to be explored thoroughly. This work intends to pave the way for unlocking the potential of VR through future research.

Key words	Virtual reality, Presence, Verisimile, Kinetics, Proxemics, Obeya, Social interaction
Further information	

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Tiivistelmä

Virtuaalitodellisuus (VR) teknologia käy läpi nopeaa kehityspyrähdystä teknologian viimeinkin saavutettua tarpeeksi korkea maturiteetti käytännön sovellusten luomiseksi kuluttajille ja yrityksille. Liiketoimintaympäristössä näitä applikaatioita voidaan käyttää yhteistyön edistämiseksi. Tämä korostaa tarvetta määritellä VR viestintävälineenä, jotta sen käytettävyys sosiaalisessa kontekstissa voidaan arvioida. Tämän tarpeen täyttämiseksi kineetiikan ja proksemiikan non-verbaalisen viestinnän mahdollisuuksia havainnollistettiin tässä työssä. Demonstratiivisen aineiston tarkoituksena on ilmentää miten VR mahdollistaa näitä non-verbaalisia kommunikaation välineitä tarjoamalla käyttäjälle luonnollisen käyttöliittymän liikkeellä ohjattavien ohjaimien ja läsnäolon tunteen kautta. Näitä kommunikaation laajennuksia sovitettiin VR Obeya konseptiin. Kyseiset sosiaalisen kanssakäymisen välineet ovat potentiaalinen hyöty tuotantojärjestelmien kehittämiseen keskittyvän Obeyan parantamisessa.

VR:n potentiaali viestintävälineenä perustuu sen kykyyn luoda käyttäjässään tunne välittömästä läsnäolosta virtuaalisessa tilassa. Tämä läsnäolo mahdollistaa illuusion kokemuksen todellisuudesta tavalla, joka saa käyttäjän suhtautumaan virtuaalisiin tapahtumiin kuin ne olisivat täysin todellisia. Tämä illuusio on suoraa riippuvainen kokemuksen uskottavuudesta ja sen kyvystä vastata odotuksia. Tässä työssä ehdotetaan, että kyseisen illuusion luominen VR:ssä tapahtuisi parhaiten, ei niinkään täydellisen vastaavuuden kautta, vaan niin sanotun verisimile:n kautta. Käyttämällä virtuaalisia metaforia kokemuksesta saadaan luotua uskottava tai semanttisesti vastaava. Tämä onnistuu hyödyntämällä käyttäjän aiempaa kokemusta, tai semanttisia kirjastoja, jotka sosiaalisen kassakäynnin tapauksessa ovat vaikkapa sosiaaliset normit.

Läsnäolon tunteen mahdollistamalla VR kokemus edistää sosiaalisen interaktion vaikuttavuutta. Verisimile lähestymistapa luo kommunikaatiosta jopa kasvokkain käytyyn keskusteluun verrattavaa. Obeyan kohdalla tämä tarkoittaisi, että VR ratkaisu onnistuisi säilyttämään kasvokkain keskustelun edut yhteistyössä, samalla hyödyntäen informaatioteknologia tuottamaa digitaalista dataa. Kuitenkin ennen kuin tämän kaltaisia etuja voidaan katsoa mahdollisiksi, täytyy VR määritellä kattavasti kommunikaatio välineenä. Tässä työssä tehtyjen havainnollistamisten on tarkoitus raivata tietä tulevaisuuden tutkimukselle tällä vielä tuntemattomalla alalla, jotta VR:n potentiaali voidaan siirtää teoriasta käytäntöön.

Asiasanat	Virtuaalitodellisuus, Läsnäolo, Verisimile, Kinetiikka, Proksemiikka, Obeya, sosiaalinen kanssakäynti
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BENEFITS OF KINETICS AND PROXEMICS FOR A CONCEPTUAL VIRTUAL REALITY OBEYA

Exploratory research on virtual reality as a medium for interpersonal interaction

Master's thesis
in Information System Sciences

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1 INTRODUCTION

Virtual reality (VR) technology has taken significant leaps in development in the last few years. This development is often tied to is the acquisition of Oculus Rift by Facebook in 2014, making a statement for the potential of VR as an applicable technology. Much of this interest is directed towards exploring VR's capabilities as a social medium, highlighting the need for understanding the concepts of communication in the immersive virtual context the technology provides. As VR offers such a unique possibility for users to dive into a virtual space, VR might even prove to establish itself as a completely distinctive communication medium. However, due to the novelty of the modern version of the technology little academic literature has yet taken on the challenge to define VR as such a medium, thus leaving a significant gap in the research of distinctive features that VR could offer for communication, especially on the applicable level.

As the wave of rapid development in VR we are currently experiencing is not the first one, there already exists significant amount of literature on the experience immersive technologies provide: presence. The fact that VR enables the user to transport themselves into the virtual and experience a self in the environment is quite apparent. This experience of self has been explored in the social setting, but the definition for VR as a communication medium is still nowhere to be found. That is the reason why this work aims to synthesize the existing knowledge and utilize it in the evaluation of the affordances that VR provides for non-verbal communication, especially regarding kinetic and proxemic cues. These additional communicational affordances are then evaluated in relation to their potential value in a lean manufactory management application: a conceptual VR Obeya.

The underlying approach in this work is defined by the idea that VR could enable interpersonal interaction more similar to face-to-face communication than any other digital medium. This proposition relies heavily on the various possibilities the VR technology provides the user. As an immersive technology VR can be seen to induce presence, thus being heavily defined by the user's own experience of the virtual space and their sense-making processes. In addition, the natural user interface, defined mostly by the motion tracking technology in VR, enables users to act beyond predefined boundaries, creating interaction that is more defined by the users themselves. This point of view is further constructed in this work based on prior literature about presence, verisimile construction of semantics, media richness and the transfer of social norms. The established framework for interpersonal communication in VR is then demonstrated through data acquired through observations. The kinetic and proxemic cues observed will also be reflected into the Obeya lean manufactory context through the construction of a conceptual VR Obeya.

The research questions in this work are:

1. What kind of kinetic and proxemic affordances does virtual reality technology provide for social interaction?

2. How could these affordances be implied to be utilized in a conceptual virtual reality Obeya application?

These questions will be answered through an exploratory research conducted through review of literature and demonstrative data gathered through participatory observations in social VR platforms: RecRoom and AltspaceVR. The kinetic and proxemic cues will are gathered from their actual use context: VR enabled social interaction. These findings are then applied in the VR Obeya context in order to assess what kind of benefits they might offer. The findings are also reflected in the user experience explored through literature on presence and the possibilities for designing VR applications that induce presence by utilizing verisimile design and leveraging prior knowledge of the user.

1.1 Terminology

Before the literature is examined a list of the key terms and concepts used within this work is presented. The list is provided in order to help the reader understand the interconnections made between the various terms along the work.

Virtual reality technology: Head mounted display (HMD) technology that features high immersive qualities and enables the user to interact with the virtual space through a natural interface.

Immersion: The technological qualities of the VR system that enable the user's perceptual shift from the physical reality into the virtual one.

Place illusion/telepresence: The experience of transportation enabled by the immersive qualities of the system enabling the user to experience that they inhabit the virtual space instead of the physical one.

Embodiment: The virtual representation of the user that enables the user to establish co-presence with others in addition to various other information.

Co-presence: The experience of others sharing the virtual space one feels telepresence in.

Presence: The subjective user experience in the shift of attention and interactional priority into the immediate virtual space around the user, presented through the immersive VR equipment.

Plausibility illusion: The subjective experience of presence high enough to enable the perception of virtual events as plausible and impactful on a level comparable to the physical reality equivalent.

Verisimile: Enabling the perception of virtual events and spaces as believable or "similar-to-the-real-thing" by using virtual metaphor leveraging existing semantic encyclopedias, instead of full fidelity.

Fidelity: The level of exactness an object or event is reconstructed in the virtual.

Semantic encyclopedias: The user's prior knowledge utilized in the process of semiosis, or sense-making.
Semiosis/sense-making: The cognitive process of deciphering the meaning of perceived objects or events, utilizing semantic encyclopedias.
Coherence: The ability of a VR system to present events and objects according to expectations, often affected by prior knowledge, in order to maintain a high level of presence or plausibility illusion.
Social presence: The expansion of co-presence to a level of presence that induces social influence from one user to another.
Social influence: The ability to affect another person cognitively, affectively and/or behaviorally.
Kinetics: Non-verbal gestures used in communication
Proxemics: Non-verbal cues communicated through the use of relative distance and mutual orientation.
Obeya: A management tool for production system development featuring collaborative information analysis and real-time decision making.
Virtual Obeya: A digital version of the Obeya tool.
VR Obeya: A conceptual version of Obeya created in this work for VR to demonstrate the communicational additions VR provides for a practical business context.

These terms are used to argue the potential of VR in enabling interpersonal interaction on levels closer to face-to-face communication than other digital mediums. This argument is based on the VR system's ability to enable plausibility illusion through verisimile interaction that is able to increase social influence. This approach is further supported with the media richness theory and transfer of social norms. The communicational abilities of VR are then demonstrated through observations made on kinetic and proxemic cues available in VR.

2 LITERATURE REVIEW

The thesis is structured so that firstly the technological definitions are specified, including VR hardware, virtuality, immersion and embodiment. Secondly the concept of presence is introduced in order to establish the unique experience that immersive VR technology is able to provide the user. The various implications VR imposes on social interaction are explored in order to create a framework on the evaluation of interpersonal interaction in VR. Thirdly the non-verbal affordances for kinetics and proxemics VR could provide are presented. Finally, the Obeya management tool is described in order to give an idea of the practical use context where the later demonstrated VR affordances could prove useful. This literature is then used to analyze the data gathered during the participatory observation period. The results hopefully help define VR as a communication medium as well as to evaluate how the medium could serve in the lean manufactory management context, or more specifically in a conceptual VR Obeya.

2.1 Virtual reality technology

In this chapter the technological definitions of virtual reality (VR) are set up. The chapter will cover the definition of VR as a technology in this work, immersion and place illusion as the technological, objective element of the broader concept of presence as well as embodiment and co-presence.

2.1.1 Virtual reality definition

The concept of virtual reality was created 50 years ago when Ivan Sutherland created the first VR headset: “The Sword of Damocles” (Chen 2015). Since then there have been two time periods when the technology stirred up a wider attention and hopes got high that the possibilities of the virtual would be unraveled. One of these periods of high attention towards the technology was in the nineties and one is currently happening. VR is often defined as the technology used in accessing the virtual, computer generated environment the user can interact in (Chen 2015). The virtual reality has been described as being just like the physical reality, but more, as there are no boundaries for human imagination in the virtual. While these high expectations never became reality due to the limitations posed by the technology during the nineties (mainly processing power) research never stopped exploring the phenomena that revolve around VR. Therefore, there exists an extensive amount of theoretical research on the possibilities of VR applications, presence and immersive technologies. This research is now beginning to unfold into an applicable

source of knowledge as the new wave of VR seems to finally push through to the mass markets with technology having reached the levels necessary to enable feasible technology with acceptable costs. (Slater & Sanchez-Vives 2016).

2.1.1.1 Technological definition

In a technological sense virtual reality (VR) can be defined to be a set of hardware that enables stereoscopic display, motion tracking and a digitally generated virtual environment that can be interacted with in real time (Steuer 1992). VR technology enables at its best a full 6 degrees of freedom (DoF) tracking which means users can move along the x, y and z axis as well as pitch, pivot and yaw their head and hands inside the virtual environment with their headset or motion controllers. This way VR offers an extension to previously known human-computer-interaction (HCI) interfaces, expanding from a 2D display and an input device (mouse, controller or finger on touch screens) to an immersive 3D natural interface (Chen 2015).

VR is therefore, as understood in this work, a set of technologies that enable a high level of sensory immersion. This technological view will be narrowed down further to a full 6DoF head mounted display (HMD), VR system that enables the usage of two motion controllers. Whether the system uses inside-out or outside-in tracking is not of major consequence as long as the fidelity of that tracking is high and enables the 6 DoF. Examples of such systems are the Oculus Rift VR headset, HTC Vive headset or the PSVR. This definition also includes the more recent versions of these technologies, given that they fulfill the set criteria. The definitive qualities of this technology are the immersive qualities that enable the user to experience presence within the virtual experience and the motion controller that enable interaction through a natural interface. This definition of technology for this work therefore excludes any other immersive reality technologies, like CAVE applications, virtual workbenches or panoramic screens etc.

Steuer (1992) brings up that defining VR merely in technological terms is rather inconvenient when developing VR outside of its technological aspects. In a communicational sense VR is seen and evaluated as a prominent communication medium enabling new possibilities for interaction through the implications on presence. The potential of VR in this sense is described as follows: “Immersive collaborative virtual environments allow users connected by a network to ‘step into each other’s world’ and provide the closest resemblance of co-location compared to other tele-collaboration technologies.” (Wolff et al., 2007). VR is therefore seen as the closest alternative to face-to-face communication, falling approximately in between direct interaction and video conferencing (Wooden 2016). This means that VR might provide the most prominent digital communication medium yet.

2.1.1.2 Virtual typology

With the terms augmented reality (AR) and mixed reality (MR) emerging more and more in the market parallel with virtual reality (VR) there is a need to specify which level of virtuality is being spoken of when examining different parts of interpersonal communication in virtual reality. Therefore, the virtuality continuum presented by Milgram & Kishino (1994) will be assessed and the scope of this work will be specified. The virtuality continuum describes the level of virtual elements in relation to the "reality" elements in a virtual system. In a social setting for example, interlocutors (people that are interacting with one another in a communication setting) may be represented as themselves or as virtual avatars. On the other hand, the environment and the objects in it can either be computer-generated virtual objects or photos of the real world. In AR virtual objects are added "on top the real world" by generating virtual objects on top of a video feed for example. In AR's case virtual objects are scarce in comparison with the physical reality ones. Therefore, the level of virtuality is low. On the other hand, an immersive VR system can have every element the user interacts with computer-generated and therefore have a very high level of virtuality. A simplified representation of this concept looks like the following:

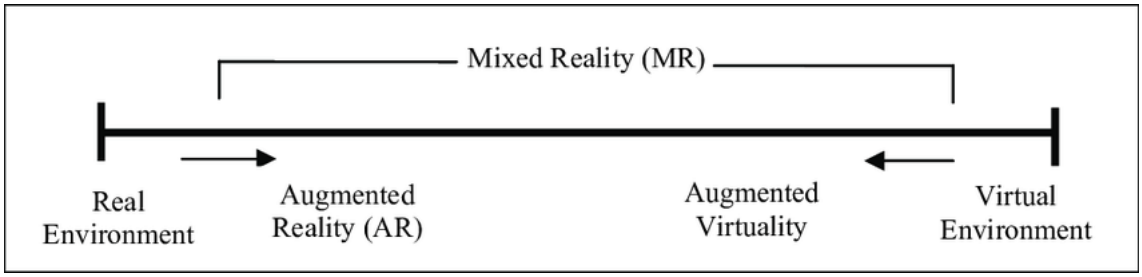

Figure 1 Virtuality continuum (Milgram & Kishino 1994)

In terms of the virtuality some specification is also needed on what is meant by words like virtual reality, virtual environment and virtual space. This specification is needed because there is a rather significant difference between the experience of the user in virtual environments like ones created for traditional video games and social virtual reality environments like AltspaceVR for example. While having little difference in virtuality from the specific point of view that both worlds have completely computer-generated objects and contain no augmentations, the user interface used is rather different. Therefore, it is specified that generally every version of "virtual" used in this thesis refers to an experience that is accessed with the earlier mentioned immersive VR technology. However due to the amount of research on collaborative virtual environments the term virtual environment is used when a connections between the laws of traditional virtual environments and virtual reality environments comply.

In this paper the term “virtual space” is used to refer to the user’s most immediate virtual surroundings. This specification to virtual reality is used in order to emphasize that a user of a VR system is indeed immersed and feels themselves to be present in a space other than the one they inhabit in the physical reality. The term virtual space also emphasizes the possibility for others to share that space, enabling co-presence and social presence and therefore affecting the communication between the individuals. Compared to the terms “virtual environment” and “virtual reality” virtual space is intended to narrow the scope of observation in order to take a closer look on what really is happening on an interpersonal interaction level. This emphasis on virtual space is supported by Slater & Wilbur (1997) as they concur that space gives a context to the overall experience and for interaction through either the environment or the people in it.

Another term used is “virtual experience” highlighting the fact that interaction in VR is highly affected by the user’s own subjective experiences. As the objects and events around the user are only a perceptual illusion the impact of these events is much determined by the user’s own attitudes and prior expectations. The user’s ability to experience the events around them as impactful has direct connection to the influence the virtual environment, or other users in it, have on them.

2.1.2 Immersion

Immersion is a strictly technological quality which describes a hardware system’s ability to provide a user attention capturing sensory stimuli. Slater & Wilbur (1997) established the qualities of immersion to be inclusive, extensive, surrounding and vivid in its ability to deliver an illusion of reality. Inclusive technology is better able to block out the physical reality. The more extensive a technology is the more different sensory modalities it provides, meaning mainly audio, visual and/or haptic. The surrounding aspect means the field of view the device provides. Lastly vividness is the quality measure of these other aspects that sum up the technologies ability to create high fidelity content that is rich in its ability to convey different information. (Slater & Wilbur 1997).

The VR technology analyzed in this work is seen to have a high level of inclusiveness and surrounding. However, the vividness and extensiveness of the technology is still seen to have space to improve. The technical parameters that determine the quality of the experience, and thus affect the vividness of the system, include frame rate, extent of tracking, tracking latency, quality of images, field of view (FoV), visual quality of rendered scene, dynamics and the range of sensory modalities (Slater 2009). The vividness of the experience can possibly be compensated through design decisions outside the hardware technology through the use of visual metaphors and “verisimile” (Marini et al. 2012), as

is explained later in this work. Regarding extensiveness, especially the haptics of the system are seen to have space to improve on, which explains the vast amount of development efforts on the market being put to the creation of haptic devices such as haptic gloves and suits.

These qualities of immersion can be seen to directly affect a technology's ability to enable place illusion, the illusion of being there in the virtual space rather than the physical space the user inhabits. Place illusion is a part of presence but does not bear all the meanings of presence (Slater 2009). It is the "form" of an immersive experience, but not the "content" as described by Slater (2003). As later defined by Schultze (2010) presence is indeed a multifaceted concept that goes well beyond the mere feeling of "being there" in a virtual environment. However the single aspect of presence called telepresence (Schultze 2010) or place illusion has been determined to be caused distinctively by perceptive qualities of the system, therefore indicating that this aspect of presence is induced solely through the technical properties of the system that enable immersion (Slater 2009).

Immersion can however be seen as a quality constructed out of multiple components and might enable more benefits than just place illusion. These benefits include increased spatial understanding, avoiding information clutter, better peripheral awareness and increased information bandwidth. Immersion and the new interface through which the user can perceive the information provided to them would therefore enable the user to process more information due to the benefits of immersion. (Bowman & McMahan 2007). These benefits are derived from the new possibilities for presenting 3D information in the virtual space, as well as the possibilities the natural interface provides for the interaction with that information.

2.1.3 Embodiment

While not being a focus in this work embodiment is introduced in order to expand the telepresence caused by immersion to the experience of co-presence within a virtual space. Embodiment is however recognized to be a hugely impactful factor even in interpersonal interaction and VR as a communication medium, yet here it is seen solely as a pre-set enabler of other features.

Embodiment refers to the user being given a graphic representation of themselves in the virtual space (Benford et al. 1995). This embodiment, called an avatar, can be seen as the link between the motion-controlled user interface and the virtual world and other users within it (Schultze 2010). Benford (1995) determines that avatars convey a variety of information to users about one another. Firstly, as the avatar is the physical representation of the user within the virtual space it is an important part of a user's identity within VR. Secondly the avatar communicates location, proximity and presence in the virtual space

to others. Therefore, embodiment is an important factor in co-presence and the ability to feel present, not just as an individual in an alternative, virtual reality, but as a social being sharing the space with others. This quality also enables the use of proxemic cues within VR. Thirdly the avatar conveys information about the user's activity as any interaction a user might have with the virtual should be animated through the avatar. This includes possible facial expressions, gestures, eye contact and other non-verbal cues. These qualities make embodiment of users an important factor in enabling interpersonal communication between users by enabling the delivery of kinetic cues.

Embodiment can be seen as a way to expand the immersion that defines the user's own individual experience to co-presence, which enables that experience to be shared, and more importantly, to affect the experience of others. Avatars are thus seen as the graphical representations that make the users present to themselves and others (Taylor 2002). Co-presence is an important enabler of social presence and the ability to influence others through social interaction (Swinth & Blascovich 2006). Given the chance to customize one's avatar, which seems to be the preferable approach regarding presence (Schultze 2010), also enables the user to communicate their attitudes through their appearance, which is an important part of non-verbal communication.

Finally, embodiment affects the experience of self in the virtual space. Bailenson & Yee (2007) have coupled embodiment with the experience of "proteus effect" where the avatar embodiment of a user affects their self-reflection. The experience of self can also be defining in the user's ability to experience the events as impactful (Schultze 2010) and can thus have a great effect on the feeling of presence and plausibility illusion (Slater 2009) as well as coherence (Skarbez et al. 2017).

2.1.4 Visualization in virtual reality

Before diving into the various theories on VR as a communication medium, mainly from the interpersonal interaction point of view, the benefits VR could introduce to data visualization are further explored. This exploration presents the additional benefits VR could provide Obeya for the comprehension of data presented in the decision-making process.

VR indeed has great promise when it comes to complicated data and especially the manipulation of 3D data (Shiratuddin & Zulkifli, 2001). Multidimensional relationships in data might even be impossible to extract without leveraging the human pattern recognition that is especially tuned for 3D spatial perception. Therefore, VR is seen as a beneficial tool in the face of the challenges big data has introduced. The complex data is hard to analyze and our evolutionary 3D spatial perception could aid in finding meaningful connections and correlations between data (Young & Munro, 1998). Carr & England

(1995) concur that: “VR reduces the need for abstract, exterocentric thinking by presenting processed information in an apparent three-dimensional space and allowing users to interact with it as if users were part of that space. In this way the evolutionarily derived processes of understanding the real world can be used for understanding synthesized information.”

The big advantage VR and immersive technologies give to data visualization is that they enable leveraging the already existing human cognition for spatial 3D information processing. Our brains have remarkable pattern recognition. However, in quantitative data especially this pattern recognition seems to be limited by the lack of proper visual exploration solutions. Creating applications for such data visualization has been made feasible by the extensive development by the gaming industry. (Donalek et al. 2014). Some research has been done to validate these promises. For example, Halpin et al. (2008) found that in the internalization of information from semantic web social network data, the ability to answer fine-grained questions seemed to significantly improve, when immersive 3D representations were used. Moran et al. (2015) on the other hand found that the challenges of visualizing big data in a comprehensive way could be eased through the use of VR. Enhanced situational awareness, utilizing familiar perception to support analysis and providing a natural interface, that enables intuitive interaction with data, all seemed to count as the benefits for using VR in data analysis.

2.2 Implications of presence for social interaction in virtual reality

This chapter introduces the concept of presence as a way to connect the various components of this thesis. Initially presence is enabled by the immersive qualities of the VR technology. In communication presence can be said to be an indicator of richness (Schroeder 2002). It gives the user an illusion of non-mediation (Ijsselteijn & Riva 2004), driving VR communication more towards face-to-face communication. When describing the sense making processes of a human-being it can be implied that the success or failure of the decoding of meaning would have a connection with presence. Presence also indicates the level of bandwidth for the transfer of social norms that a VR system enables (Schroeder 2002). Presence can also be defined as a measure of social richness that was enabled by the affordances of the medium (Lombard & Ditton 1997). Presence is therefore presented here as a factor affecting the overall success of creating a VR communication medium, or a VR Obeya, as it is seen to summarize many of the features that define a good communication medium. In the best-case scenario presence develops all the way to plausibility illusion, ensuring the experience to have real impact on the user (Slater 2009).

2.2.1 Plausibility illusion

In order to further explain the possibilities of VR to create realistic-feeling experiences, plausibility illusion is introduced. This concept means to expand the concept of presence from what can also be called place illusion, the feeling of being there, to the feeling that the events perceived are real. This expansion has been motivated by various experimental research on presence and the finding that research subjects don't only feel a transition in place but can actually be noticed to have clear response to the events in the virtual environment they transition to. These findings would imply that VR users can experience the virtual as plausible, actually happening and therefore impactful on a whole different level compared to other digital mediums. (Slater 2009).

In order for plausibility illusion to occur the user needs to be situated in circumstances where the produced events relate to the participant's prior knowledge (Skarbez et al. 2017) and are credible on high enough level compared to expectations (Slater 2009). This means that in order for the user to be willing to believe the events are happening and to internalize them, the events need to match what the user is already familiar with. This willingness to believe is an important factor in VR as much of the experience relies on the user's attitude towards the whole experience. (Skarbez et al. 2017).

One possible approach to enabling plausibility illusion could be designing the VR experience to be verisimile. Verisimile refers to the virtual space and the social interaction in it to be believable or "similar-to-the-real-thing." Through this approach the VR experience would not be designed to have full fidelity but would instead utilize virtual metaphors and rhetoric to create experiences that are able to depict semantically equal meanings while still being virtual. Fidelity here refers to the degree of exactness a feature or an object is copied or reproduced in. (Marini et al. 2012). In social interaction plausibility can be induced through the use of verisimile interaction, which means the use of non-verbal cues familiar from physical reality reconstructed in the virtual through the use of the natural interface and presence.

The evaluation process of how plausible or believable the experience is can be seen to follow the same sense-making logic human beings use in all situations. In semiotics terms this process of sense-making is called semiosis. Semiosis is a cognitive process where a person deciphers the objects or events they perceive based on their prior experience. This prior experience is cumulative and forms a semantic encyclopedia of meanings within a person's mind. (Barricelli et al. 2016). The deciphering process has the highest probability of success when the expectations of the person are met (Marini et al. 2012). This would imply that the success of any communication process in VR is not reliant merely on the system, but on the user's ability to make sense of the virtual rhetoric they are presented with. In addition, much due to the fact that VR is such a novel technology that no semantic

encyclopedias for it can be expected to have been formed, the user will indeed rely on their prior knowledge when inside the VR experience.

Coherence is the VR experience's ability to maintain logical consistency on a level that does not break presence, or more accurately the plausibility illusion (Skarbez et al. 2017). Coherence can therefore be seen as a measure for the VR system to continuously depict information that is verisimile and therefore impactful. It draws from the idea that in order for a user to believe what is happening around them is actually meaningful on the level of it being real, one needs to encounter reasonable circumstances. These reasonable circumstances can be determined to be events and logics that the user is able to make sense of, according to prior knowledge. Coherence is based on the idea that the user is constantly questioning their environment, actively looking for anomalies and assessing the quality of their experience. When reasonable circumstances are not met the user experiences a break in presence, a moment of disbelief towards the immediate virtual surroundings which dissolves the illusion of the experience being real. (Skarbez et al. 2017).

Another component that is incremental for plausibility illusion is that there are events happening that relate to you, the user, that are in no way controlled by them (Slater 2009). This means that the user will believe that an experience in VR is meaningful when they are not just a subject of actions and events but also an object of them. This experience that you did not initialize an event, but have to react to it, seems to impose plausibility illusion. This can also be called a shift in causal priority (Schloerb 1995). The enhancement in the realness of the environment you are in might stem from the fact that as a VR user you know for sure that you yourself are real, therefore events addressing you must have real meaning. Heeter (1992) has found this kind of experience to occur especially in a social setting. Social interaction seems to be a powerful way to validate that an event is real and therefore has meaning.

2.2.2 Presence

Presence is seen as a core element in VR, the one that differentiates VR from other communication mediums. Therefore, the analysis on presence will set the contextual reality in which social interaction happens and therefore accounts for a major part in this work. Presence can be seen as a multifaceted concept and has received much attention in previous research. As such the most important factors affecting presence depend on the point of view. In order to create a sufficient and coherent understanding on the phenomenon of presence these forms and theories of presence will be presented and evaluated in order to comprehend how they relate to social interaction within VR.

The most traditional form of presence is telepresence and the experience of transportation that immersion creates. In this work this form of presence was covered along with

immersion as the result of immersive technology inducing what can be called “place illusion” (Slater 2009). Slater, along with Witmer and Singer, and many other scholars have however tried to broaden this view on presence to include a variety of other qualities, thus creating the many forms we know today. Slater (2003) divided presence into form and content, where form refers to immersion and content to the ability for the experience to engage the user. Witmer & Singer (1997) defined presence as involvement, in addition to the immersive qualities that are created through the sensory stimuli. This involvement can be seen as the allocation of attentional resources from the physical reality into the virtual events surrounding a person. Schloerb (1995) called this phenomenon a shift in the causal priority. This shift in attentive resource or causality is what is seen to expand place illusion to plausibility illusion (Slater 2009). In the social setting presence has been researched through the bandwidth of social norm transfer (Schroeder 2002), the social richness of a medium regarding affordances (Lombard & Ditton 1997) and in relation to personal, social and environmental presence (Heeter 1992).

The theories on the causes of presence vary, yet all follow many similar logics. It seems that immersion and the sensory feedback one receives are seen as an important factor, along with the quality of that feedback (Slater & Usoh 1993), its extend (Sheridan 1992) and vividness (Steuer 1992). In this work these are the technological features that form immersion. Additionally, interaction is seen as a major contributor. The user needs to be able to control or influence the environment they are set in (Slater & Usoh 1993; Witmer & Singer 1998; Steuer 1992; Sheridan 1992; Lombard & Ditton 1997). Interaction with the environment brings in many implications. On the personal level interaction creates the demand for the virtual experience to give the user feedback as expected (Slater & Usoh 1993) in order to present a credible (Slater 2009) or believable (Marini et al. 2012) experience. Therefore, the evaluation of the interaction is an ever-going process which relies heavily on the user’s “willingness to believe”. If expectations are not met the user can experience a break in presence, often causing a drop in engagement with the VR experience. This feature was previously named the coherence of the system. (Skarbez et al. 2017).

The views on presence can be summed into four different theories assessing different aspects of the experience. The first theory depicts the VR experience from a mere sensory feedback point of view. In this point of view the immersive qualities of VR technology create a level of fidelity that enable the user to understand and be convinced of the environment generated around them, referring to immersion. The second theory is the experience of self and the embodiment of a user. In order for experiences to feel impactful and for one to feel involved in them a user needs to perceive a self as a part of events happening around them. As embodiment through an avatar is the process of getting a computer-generated representation of self, the system’s ability to create a version of the user that they themselves are willing to accept becomes an incremental part of the embodiment

design, as well as the overall VR experience. (Schultze 2010). These two theories are seen to construct the context for social interaction in VR. Immersion and embodiment are seen as the technological setup that enable a person to perceive and inhabit a virtual environment and therefore enable any kind of interaction and involvement with the virtual space and other users in it.

The third theory concentrates on the interactional fidelity of the VR system. According to this theory the level of presence is determined by a user's ability to interact with the virtual environment, and other users in it, in an intended way. This presents a task orientated view on VR where the fidelity of the system is determined more by the behavioral fidelity of the system rather than the fidelity of the sensory stimuli the technology provides. (Schultze 2010). At the moment the goal for behavioral fidelity could be the concept of verisimile (Marini et al. 2012). By enabling similar semiosis (Barricelli et al. 2016) in VR and in real-life, a social VR application might be able to transfer social norms and behaviors into VR, and therefore enable VR to develop into a communication medium with the levels of richness that face-to-face communication enables.

The fourth theory depicts the process of directing attention to the events happening in the virtual space one is immersed in. In other words, it is the evaluation of the cognitive capacity a user directs between the real, the internal and the external/virtual worlds. Immersion aims to ensure the user is able to direct minimal focus on the real world and instead be maximally engaged by the external events of the virtual space they inhabit. The shift of attention between the internal thoughts of a user and the events happening in the external environment on the other hand depend more on the coherence of the experience and lack of breaks in immersion – as well as the individual's personal qualities. (Schultze 2010). The process of directing attention can be seen as a rather definitive quality in VR. In interpersonal communication this attention determines the level of engagement one has in the social interaction and thus affects social influence.

All the accumulated knowledge about presence and the various aspects of the user experience in VR can be summed up into a logical framework depicting the process of presence from technology to presence and all the way to plausibility illusion.

1. Immersion as technology: FoV, graphics, 6DoF, motion tracking, vividness, perceptual modalities etc.
2. Immersion as experience: telepresence/place illusion
3. Embodiment of user: avatar, co-presence
4. Interaction: affordances, natural interface
5. Attention: allocation of cognitive resources, involvement, shift in causal priority

→ These features enable an experience that is verisimile and able to induce high levels of presence or even plausibility illusion.

This process is a definitive one to VR as it differentiates VR from other communication mediums by enabling the user to be present in the environment both in relation to self and to others. This process of interpreting the virtual environment and its impact is what creates the possibility for VR to ever reach the levels of face-to-face communication in interpersonal interaction. The implications of presence for social interaction are further explored through the concept of social presence in the next chapter.

2.2.3 Social presence

Swinth & Blascovich (2006) approaches the issue of difference in computer mediated communication (CMC) through the concept of social presence. This term stems from the idea that the presence of others enables some level of social influence from one to another. Social influence can be roughly defined, in social psychological terms, as activities that trigger affective, cognitive and/or behavioral social responses in another person. The amount of influence is affected by the telecommunications medium used and its ability to convey information that is meaningful for the interpersonal interaction that the media facilitates. (Swinth & Blascovich 2006). The amount of social presence is affected partially by the level of co-presence but is mostly defined by the ability of the system to convey verbal and non-verbal communicative signals from one interlocutor to another (Böck & Mühlbach 1993). These verbal and non-verbal cues can be utilized to manage the level of intimacy or immediacy between interlocutors (Lombard & Ditton 1997).

One approach for increasing social presence could be the establishment of a verisimile experience that leverages our prior knowledge (Marini et al. 2012). In social interaction the semantic encyclopedias needed to be transferred are social norms. Goffman frames are used here as they explain the process of how people interpret interaction in relation to social norms. A central presumption is that people want to present themselves as acceptable in the social context and therefore aim to act within norms. When one fails to do this, they feel embarrassment, which in Goffman's theories is seen as a main indicator of failing to act within the appropriate frame. (Miller 1995). According to the research done by Dzardanova et. al (2017) this idea of embarrassment when failing to act according to the social norms would seem to apply even in VR.

However, the presentation of an acceptable self is heavily affected by the richness of the medium and the expressive resources given for the individual to present themselves appropriately (Miller 1995). Richness is here defined through the media richness theory by Daft & Lengel (1986) that defines a communication medium based on its ability to transmit different forms of information through sensory modalities. Richer media provides more cues, immediate feedback loops, personalization and language variety. (Daft

& Lengel 1986). This ability to transfer social norms can also be called the systems bandwidth (not to be confused as the technical term). A connection has also been established between bandwidth and the experience of presence within a VR medium. (Schroeder 2002).

Social presence could therefore enable verisimile interaction between users in VR and could thus increase plausibility illusion and the overall impact of the interpersonal exchange. This experience could be described as the illusion of non-mediation (Ijsselteijn & Riva 2004) which would imply that social interaction through VR could indeed enable the user to forget their communication is mediated digitally and would therefore enable the social interaction to be interpreted as plausible and impactful on the level of physical reality. This would propose that social interaction alike to face-to-face communication could be possible through the immersive VR technology, in theory.

Presence can therefore be seen as a system's ability increase the transfer of social norms, or bandwidth, as well as its ability to increase richness (Schroeder 2002). By increasing social presence one can increase their social influence on another (Swinth & Blascovich 2006) and thus enable impactful engagement between users and help in the creation of social bonds. Strong social bonds can even be seen as a prerequisite for the exploitation of any information outside the immediate scope of the interaction context (Gressgård 2010). However, in order to enable the creation of social bonds in VR one needs to provide the user a level of confidence with the medium in order to promote active interaction through the novel interface, that at times can prove challenging for new users. (Holopainen et al. 2018). The use of the interface relies on the affordances given for social interaction (Lombard & Ditton 1997). In this work this richness is explored in the form of kinetic and proxemic cues, which will be explored next.

2.3 Affordances for non-verbal communication in virtual reality

The concrete dimension that enables the benefits VR could provide social interaction are the affordances the newest VR technology provides. The immersive qualities, that enable the user to be present in the space with others, and the motion controllers, that enable real-time manipulation of the avatar of the user, are what make VR richer as a medium (Otto et al. 2006). They also define the semiotic processes within VR and enable the transfer of social norms into VR. Presence and the natural user interface are the differentiating factors of VR compared to other mediums. These technological qualities are applied into social interaction through their use in non-verbal communication. Communication is defined here as an act of influencing another through one's behavior by utilizing socially shared symbols, signs and semiotic rules (Wilson 1979, Mandal 2014). VR technology

provides the users new affordances that enable them to use gestures and proximity to cue a variety of information within the social spaces in VR.

Non-verbal communication is not limited to just kinetics and proxemics. As a huge part of communication, covering 65%-93% of meaning communicated by a message varying based on the view (Hans & Hans 2015), non-verbal communication includes multiple different parts. The broadest categorization is that of verbal-vocal, nonverbal-vocal and nonverbal-nonvocal (Mandal 2014). Here the concentration is in nonverbal-nonvocal as the vocal parts are not something that VR would significantly expand, audio remaining quite similar in VR compared to other digital communication mediums. As the "silent language" non-verbal communication includes body motion and gestures, attitudes towards time and space and general habits in communication. Another categorization for non-verbal communication divides it into seven different parts: kinetics, appearance, touch, paralanguage, proxemics, artifacts and environmental factors. (Wang 2009). The variety of cues and information these parts convey are used to support social interaction and to communicate a variety of social and affective meaning from one person to another (Cristani et al. 2011). Culture, time, context and individual characteristics all play a big role in communication and form interpersonal interaction as we know it, at least when coupled with verbal communication and language.

In order to set up what kind of behaviors might be available for VR in the case of interpersonal communication we will take a short glimpse at one of the many sides of presence. Presence as a measure of social richness focuses on a medium's ability to bring affordances usually connected with non-mediated, face-to-face communication These affordances can be used to balance the levels of intimacy and immediacy between users. Some affordances that are required to positively influence the interaction between users are physical proximity, eye contact, facial expressions, posture (including arm positioning and body orientation and relaxation), gestures, touching, olfactory cues and the various audio cues like speech duration, audio quality, intimacy of conversation topic and laughter (Lombard & Ditton 1997). These behaviors are balanced in order to establish an equilibrium between approach and avoidance forces in order to establish an appropriate level of intimacy (Argyle & Dean 1965; Lombard & Ditton 1997; Yee et al. 2007). Failing to maintain equilibrium induces instant emotional reaction: too intimate makes one feel anxious while the lack of intimacy induces feelings of rejection (Argyle & Dean 1965). This can also be seen as an example on failing to follow social norms and presenting an acceptable self (Miller 1995).

2.3.1 Kinetics

When looking into the various communication through the user avatar one needs to take into account the device used in the manipulation of that avatar. Usually there are three approaches on displaying non-verbal cues which are direct controllers, user guided animations, or "emojis", or autonomously controlled communication (Fabri et al. 2004). The two latter options are present in VR partially due to avatar design leveraging previous virtual environment designs like ones in video games, or merely the intuitive digital communication design of Facebook messenger for example (Antonijevic 2013). How enrichening the interface is, is based on the direct control that the motion controllers provide, as they enable real-time interaction, that is mostly applied by the user themselves.

The utilization of the direct motion-controlled interface enables a variety of gestures to be used in VR. These gestures can be ambiguous in meaning and often derive their meaning from context. The vagueness of the meaning the gesture bears decides its place on the lexicalization continuum that can be used to explain the variety of different gesture categories. (Krauss et al. 1996). On the vague side of the continuum are the adaptors that bear no specific meaning but can be used as a method for expression. In the middle are the illustrators, or conversational gestures (Krauss et al. 1996), that are the most used and usually derive their specific meaning from the context they are used in. The most specific gestures are called emblems, or symbolic gestures (Krauss et al. 1996), that have an agreed-upon meaning. (Krauss et al. 1996; Mandal 2014; Hans & Hans 2015). These gestures are combined with one another to support communication. Illustrators often provide aid for the listener to decode meaning. Adaptors help the speaker vent their internal feelings, often unconsciously and emblems aid the interaction by providing clear means of communication without the use of vocals.

Different gestures can be seen to be used for different purposes. Gestures can pace an interaction (McNeill 2007), have a significant role in the turn-taking behavior of an interaction (Poyatos 1983), communicate affection or merely support the social interaction (Cristani et al. 2011). Mostly they are used as a support for verbal messages. In this task different gestures can take the following functions (Ekman & Friesen 1969):

- Complementing
- Accenting
- Repeating
- Contradicting
- Regulating
- Substituting

Complementing gestures are used to support the overall message by clarifying or by reinforcing it. For example, deictic gestures like pointing or showing relative distance (Li et al. 2018). Accenting gestures emphasize a part of a message. For example, throwing

one's hands in the air dramatically to emphasize the strength of an emotion. Repeating gestures repeat the verbal message, such as shrugging one's shoulders when indicating the lack of knowledge. Contradicting gestures are often used in sarcasm or other situations where the message is being altered towards opposite of the initial meaning. Regulating gestures include raising one's finger to avoid another taking the turn to speak before you are finished, for example. Substituting messages are often emblems as they are used to replace the verbal message through a gesture. (Ekman & Friesen 1969). It should be noted that gestures here include also head movements that often communicate the acknowledgement of others and the direction of attention and interest (Hans & Hans 2015).

Additional definitions for gestures include spatiotemporal definition and semantic definition. Gestures can be static or dynamic in space, based on the display method. Dynamic gestures used provided through a natural interface offer variety, especially in regards of chromatics, which can affect the meaning of a gesture rather significantly. (Li et al. 2018). It also matters whether gestures are conscious/unconscious (Ottenheimer 2005) or intentional/unintentional (Pavlovic et al. 1997). The analysis of one's behavior can tell a great deal on their current state of mind, or even personality, as confident, insecure, relaxed, fearful or embarrassed etc. people tend to act differently (Mandal 2014).

Illustrator gestures can also be broken down to five sub-categories: beat gestures, iconic gestures, deictic gestures, metaphoric gestures and cohesive gestures. Beat gestures are quick, repetitive movements. Iconic gestures are used to act out a situation or action using one's hands. Deictic gestures are pointing gestures to establish the location or relative distance of objects. Metaphoric gestures aim to depict abstract things through simple expressions. Cohesive gestures are used to link together topics from a separate temporal context. (McNeill 2007).

2.3.2 Proxemics

It had been established earlier in this work that the immersive qualities of VR enable co-presence through enabling place illusion to embodied individuals sharing a virtual space. This presence in the same space can be seen to create mutual awareness (Fabri et al. 2004). This expands into social presence that enables social influence in interpersonal interaction (Swinth & Blascovich 2006). Yet even the mere co-presence of users in a shared virtual space provides the possibility to utilize another non-verbal cue: proxemics.

Proxemics depict the often-unconscious management of distance between individuals (Cristani et al. 2011). This distance between interlocutors is one of the factors in the equilibrium theory, where individuals manage the level of intimacy between one another (Lombard & Ditton 1997; Argyle & Dean 1965; Yee et al. 2007). The significance of distance can be seen in language as well. It is common for people to say they are "close"

or “distant” to someone when describing the level of friendship. (Hans & Hans 2015). In dialogues personal distance is often managed through personal space, where an individual has normatively established zones around them that affect their positioning in relation to others. In larger groups however these personal distances are replaced with what can be called “F-formations.” (Cristani et al. 2011). It has also been established by Bailenson & Blaschovich (2003) in their study towards interpersonal distances and proxemics in VR that people do indeed regard avatars and virtual humans similarly as they would real people when regarding proxemics.

The personal distances are as follows: 45 cm for intimate, 1,2 m for personal, 3 m for social and from there on public. In addition, the backside of a person allows closer proximity meaning one does not mind people intruding their personal space if it happens behind their back or even sides. The various spaces bear different effects to interlocutors and are associated as normal for certain kinds of interaction. In general, it has been established that the public space is mostly relevant in giving speeches and in that context gives a speaker a sense of power or high profile. Engagement with people is not obliged in this space. In the social space our cognitive efforts increase as we usually engage in one-on-one discussions in this space. The space enables discussion between recognized individuals without inducing personal relations and is therefore common in professional or formal relations. The personal space is divided to outer personal space (0,8-1,2m) and inner personal space (0,5-0,8m). Generally, this space is intended for people that have close relations with touch being the separating factor between an individual’s access from the outer personal space to the personal space. Yet touch in this space still means platonic, not romantic interaction. The last zone is the intimate space which people only let others in in greetings with close friends or when interacting with a romantic partner. (Bailenson & Blashovich 2003; Cristani et al. 2011; Hans & Hans 2015). It should be noted that the inner personal and intimate zones are lessened in importance in VR due to the lack of haptic feedback and therefore the exclusion of touch. It is also often culture specific on how people vary the distances within the zones, meaning whether they interact in the outer or inner edges of a zone, while the zones themselves seem to be rather universal (Cristani et al. 2011).

Proxemic behavior is often guided, or even dictated, by physical space and the restrictions it poses. Yet people still have ideas on the ideal formations groups want to take. These formations are called F-formations and they address two key needs in a social situation: the possibility to participate and the separation of the group from other individuals. F-formations are created whenever two or more individuals arrange in space and orientation in a way that establishes an area where these people have equal, direct and exclusive access. These formations can take a various form, most common of which are the circle, the L-shape and standing side by side. (Cristani et al. 2011).

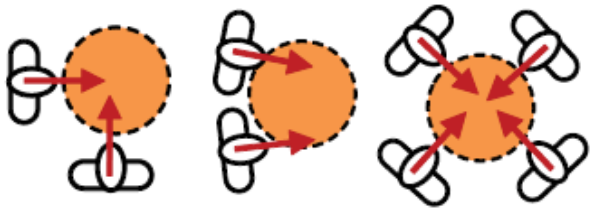

Figure 2 Examples of F-formations (Cristani et al. 2011, modified)

The grouping behavior that the F-formations depict is an example on human terrirotial behavior. People have a need to claim a space for themselves and, by forming in the given ways for example, to create “invisible barriers” that others cannot merely ignore. It is indeed apparent that intruding in an established territory will lead to a negative reaction. (Hans & Hans 2015).

Both dialogues and group interactions utilize mutual orientation, which is established through body-orientation and eye-contact (Cristani et al. 2011). While the details of both the body and the eyes, as well as all facial expressions, can be expected to be significantly lower in fidelity in VR compared to the physical reality, they can still be utilized in directing and communicating one’s attention and interest in social interaction in VR. This shift of attention can be utilized in various situations, such as turn-taking behavior (Hans & Hans 2015). Eyes are also our main perceptive sense. In addition to showing attentiveness and interest, eyes are also used to gather information about the engagement and attention of others. (Hans & Hans 2015; Argyle & Dean 1965). The amount of eye-contact varies within a conversation according based on the experienced equilibrium of intimacy. We adjust the level of eye-contact according to things such as the point of conversation, nature of topic or relationship between interlocutors. The main functions of eye-contact are information seeking, affecting others, signalling attention and expressing internal emotion. (Argyle & Dean 1965). It is further highlighted however that the lower fidelity of VR compared to physical reality in regards of facial expressions, and thus the many micromovements of the eyes, can reduce significantly the extent to which eye-contact can be utilized in VR. Therefore, the feedback received through one’s eyes can also be distorted, leading to possible miscommunication.

2.4 Virtual reality obeya

As a practical application for this study Obeya, the production system development tool originally created by Toyota, will be introduced. Obeya is a lean manufactory concept that brings key decision makers to a single room with all necessary information presented for real-time decision making and action. This context has been chosen for this work to make the virtual space where interpersonal interaction is to take place in more concrete.

While Obeya itself is a rather interesting concept, it will work here as a mere example for a VR communication context. Yet as Obeya has already been established to work in the traditional, physical reality way, and various digital versions of the tool are being introduced to the market, it is interesting to see whether VR could provide further improvements to it, especially regarding interpersonal interaction.

When looking at the virtuality continuum (Milgram & Kishino 1994) presented we can pick out the two emerging mixed reality (MR) technologies that are gathering more and more interest everyday: AR and VR. In the world of practical applications there has already begun to emerge a rather significant differentiation between these technologies, especially in the business application context. AR is seen as a potential technology to be used "on the run" in maintenance, assembly, quality control or navigation. Augmentation of reality serves well in providing an additional layer of information in the real world in order to assist operations, which gives AR a highly mobile nature. VR on the other hand seems to be applied instead in training, design, development and planning. While AR adds information to an existing physical environment VR requires the complete recreation of that environment. Therefore, VR naturally falls into its place before action, as a virtual sandbox where various design choices, simulations and other preliminary information can be virtually presented and assessed in order for people to make better decisions. As a prominent decision-making tool, VR thus presents a potential platform for Obeya application.

2.4.1 Obeya

Before introducing the benefits that VR might be able to offer Obeya the underlying concepts need to be specified. First lean manufacturing principles which are behind the Obeya tool, then the Obeya itself in its traditional form. After that the digitalization of the Obeya tool will be introduced. Only after these three parts have been covered can the hypothetical VR Obeya be constructed in the conclusions, as the benefits VR might be able to provide this management tool will be implied.

Lean manufacturing is a philosophy that aims to perfect production by minimizing all waste without compromising effective production. This management method originates from Toyota and has become a dominant paradigm for many organizations. The underlining idea is that it is possible to draw a value map of the processes of the organization and highlight all points where value is created, while removing points that do not create value as waste through continuous improvement efforts. (Womack et al. 1990; Holweg 2006; Terenghi et al. 2014).

Obeya itself is an example of a lean solution, as it aims to reduce waste in the decision-making process. As an innovation support tool for production system development Obeya

is a visual management tool used in lean manufactory that drives active collaboration and decision making. Production systems can be developed either through incremental, continuous improvements or through less frequent, radical changes in production. Obeya can be used to support both of these forms of production system development. (Javadi et al. 2012).

In practice Obeya is a space where the walls are filled with visuals depicting organizational and process data that people gather around. In traditional, physical Obeya information is mainly visualized through A3 sheets and post-it notes. Analogies drawn from Obeya connect it to a war room, a bridge of a ship or a brain. It aims to centralize taking action into a space filled with information and collaboration. When used correctly Obeya also decreases departmental thinking and promotes transparency. An important notion is that an Obeya is not a meeting where members of teams, neither executives nor management, report extensively on daily activities. Instead focus is directed to tasks at hand and decisions to be made. Data presented is often not visualized completely but instead they are worked on together in order to create discussion and active thinking. (Jusko 2016).

Obeyas have improved these development processes quite a bit by reducing rework, reconsiderations and unnecessary discussions while enhancing rapid decision making (Terenghi et al. 2014; Aasland & Blankenburg 2012). These improvements should ensure the benefits in efficient development processes and quality of the products designed (Aasland & Blankenburg 2012). One of the benefits of Obeya is to avoid the "broken phone" effect where misunderstandings and miscommunication are created by people explaining decisions made further to relevant personnel. By bringing every relevant member to a single room Obeya enables resolution of miscommunication on the spot and does not give space for those misunderstandings to take lives of their own. (Terenghi et al. 2014). As communication is open between all the key decision makers present it promotes cross-functionality and decreases departmental and hierarchic thinking. Obeya thus gathers all relevant data and people in the same place in order to speed up the whole plan, do, check and action cycle and promotes open and active communication in production development. (Javadi et al. 2012). Obeya therefore brings all information and people are in the same place, speeding up decision making while maximizing value created.

2.4.2 Virtual Obeya

As mentioned before the traditional Obeya brings all decision makers to a single room where relevant information is presented. The common way to present this information has been through A3 sheets and post-it notes where the people present manually draw the graphs and numbers needed to make informed decisions. While the manual processing of

information in real-time remains a relevant part of digitalized Obeyas, the A3 sheet visualization has been established old fashioned quite a while ago. Therefore, updating the Obeya practices to modern standards requires the creation of a digitalized Obeya that is integrated to the information infrastructures that contain the information and data relevant for decision making (Terenghi et al. 2014). In addition, this development towards a digitalized solution is motivated by the increase of geographically dispersed operations, establishing a need for remote collaboration (Aasland & Blankenburg 2012).

In order to digitalize the Obeya and thus create what is called the virtual Obeya one would need to include the recent development in information architecture, enabling smarter integration of data and distributed collaboration. Virtual Obeya would enable benefits in direct manipulation of digital data, collaboration beyond the confinements of a single room and asynchronous communication between team members in different time zones. (Terenghi et al. 2014). The goal for a virtual Obeya is therefore to combine the visual, physical and virtual elements of Obeya. This means information should be effectively visualized, interpersonal interaction should be enabled on as close to the levels of physical face-to-face as possible and the digital communication enabled should solve the issue of geographically dispersed teams and key members. (Aasland & Blankenburg 2012). The goal is to benefit from the vast data collected through existing IT-systems and utilizing the visual automation qualities of these systems to partially automize data visualization. However, as Obeya is at its core a communication tool, establishing sufficient support for collaboration both in data manipulation and audio/video/text-based communication is incremental.

A variety of virtual Obeyas already exist in the market in different forms. Some provide a straightforward dashboard view with relevant processes and their information while others aim to create custom build solutions for specified context. Here a general overview on the qualities a virtual Obeya should provide are covered in order to create a good base from which to move on to the design of a VR Obeya. A virtual Obeya should therefore allow at least (Aasland & Blankenburg 2012):

- person to person communication
- seeing each other's computers
- posting and reading posts
- updating as new things happen

A common way to recreate Obeyas in the virtual is the introduction of touch screens to enable natural manipulation of information common to traditional Obeyas. In addition, the high levels of information visualization can be recreated through generous use of computer screens. Information retrieval should be semi-automatic, maintaining the chance for active data manipulation/visualization in order for the collaborators to highlight relevant information in discussions. (Terenghi et al. 2014). This means that in practice virtual Obeyas are quite technology intensive (full wall covering screens, big ones

and small ones, multiple cameras, good audio through high quality microphones and speakers etc.) as effective visualization that enables collaboration on the level that is required in Obeya poses quite a challenge. (Aasland & Blankenburg 2012). It should also be noted that this covers just the hardware requirements for improving the visualization of Obeya through digital means.

On the software side virtual Obeyas can be constructed through a variety of applications, or widgets, that recreate the functionalities of the traditional obeya. Most useful of these are the ones that are capable of performing semantic searches on predefined databases. These semantic searches form the data behind the visualization of the value creating processes that are the target of development. Visualization itself happens through widgets, which are basically different applications for viewing different data-formats that are viewed through the fore-mentioned screens. (Terenghi et al. 2014). Creating the virtual Obeya is therefore more about integrating existing software infrastructure with the presentation and collaboration hardware solutions.

While the virtual Obeya does create some obvious benefits in remote collaboration and in the utilizing of existing digital databases it does impose some restrictions to the overall collaboration that Obeya aims to create. For example, the manipulation of data through digital interfaces needs far more protocol than mere drawing of graphs on a A3 sheet. Therefore, the creation of a virtual Obeya needs to take into account the timely updating of information, and especially changes in that information, to the other devices taking part in the collaboration. (Terenghi et al. 2014). In addition, the digital user interface will provide the user with valid actions, therefore restricting the information manipulation to those actions. When used through a traditional desktop interface these actions might prove unintuitive and might require additional training, creating thus an additional barrier for the utilization of virtual Obeya.

2.5 Summary

The base assumption made in this work was that VR could possibly enable interpersonal interaction on levels similar in impact as face-to-face communication. This bold statement was supported by various views in literature. Through verisimile design and the use of virtual metaphors that utilize our prior knowledge, or semantic encyclopedias, one could produce an interaction setting into the virtual where users could experience plausibility illusion. The plausibility of the experience is seen to be supported by increase in richness and the transfer of social norms, much enabled by the many aspects of presence.

Presence is the differentiating factor in VR that defines it as a communication medium. VR technology enables presence by first enabling place illusion through the immersive technological qualities, along with embodiment and co-presence. When perceptually

transported from the physical to the virtual the user is able to interact with their immediate virtual surroundings as well as able to shift attention to it. This allocation of cognitive resources, or shift in causal priority, creates an illusion of non-mediation and increases social presence when situated in a virtual space with other users. Social presence in turn increases social influence and the ability for the users to create social bonds with one another, which can be seen as a prerequisite for the use of any external knowledge.

In practice the social influence gets communicated through the additional non-verbal cues the natural interface and presence enable in the VR: kinetics and proxemics. Through these concrete cues, users are able to manage equilibrium and intimacy in order to act within social norms. These additional abilities for communication can also be utilized in the lean manufactory management tool, Obeya. As a tool for active decision making Obeya relies on the facilitation of collaboration and information analysis in order to enable real-time decision making on the improvements of the production systems. The social interaction enabled by VR could be utilized in Obeya by creating a virtual version of the application in VR that would better maintain the best parts of both existing solutions. By enabling the virtual, the VR Obeya could offer benefits for remote collaboration and modern data visualization and analysis. Through immersion VR Obeya could invite the collaborators to join in in a shared space and would enable social interaction more alike the traditional, physical reality Obeya. These possibilities are demonstrated next through the data acquired during the participatory observation period in the social VR platforms.

3 METHODOLOGY

The research was conducted as an exploratory research with aims to better understand VR as a communication medium, especially in its current technological development stage. A participatory observation was conducted in order to perform an ethnographic research on how well does VR enable social influence in social interaction. The ethnographic method was chosen in order to efficiently explore a field where current expertise could be seen as insufficient, therefore highlighting the need for practical knowledge on the actual state of VR communication, rather than the intended state of things, which professionals in the field could be expected to provide. Due to the nature of the technology under research, the communicational processes that happen in the interpersonal interactions in VR can be seen as affected more flexibly by the user's experiences of presence and plausibility and the flexibility the natural user interface provides to the interaction between users. Communication in VR is therefore seen to be defined by the social context it is used in, thus establishing a unique cultural environment for communication.

Ethnographic research is most commonly used in anthropology in order to obtain deeper understanding about social and cultural constructions in the researched context. The definitions of culture may vary, yet it usually refers to the beliefs, values, attitudes and shapes of behavior of people in a particular context. (Merriam 2002). Here the behavioristic characteristics are highlighted as well as the cognitive constructions that people utilize in deriving the semantics of the events around them. The interconnections between interaction and communication between the virtual and the physical realities are explored in order to establish how VR could function as a communication medium, highlighting the experience of presence and social influence of an individual in VR.

The observation data used in this work to demonstrate the possibilities VR provides for interpersonal interaction was gathered in two social VR platforms: RecRoom and AltspaceVR. These platforms provided an easily accessible source of uninfluenced data on what extent does the current technology enable the use of non-verbal cues in social interaction. The data was collected through participatory observations with the researcher actively engaging in social interaction with the other users in these public virtual spaces. The researcher did not actively establish that they were conducting an observation research within the spaces in order to not affect the possible interaction. While the ethical challenges of this approach are quite apparent, they are not seen as defining, as the interlocutors engaged with were virtual avatars within a public virtual space, being identifiable through username only. In addition, no personal information was recorded about the observed individuals, as the demographic information was not seen to affect the quality of the data gathered.

The reliability of this research is ensured by the accessibility of the platforms where the observations were conducted in. While the interactions cannot be fully reconstructed,

the various non-verbal cues that were observed can be recognized by any other observer within the platforms. The reliability is also supported by the fact that any interactions recorded were completely non-altered, thus depicting the communicational capabilities of VR as a medium precisely as they are. The validity of the research is affected by the subjective nature of the participatory observation method. Therefore, any exhaustive conclusions cannot be drawn from the data gathered. However, based on the demonstrations made and the prior literature explored this work is seen to be able to shed light on the matter of social interaction within VR and is thus able to expand existing knowledge in this rather unexplored field.

The research questions in this work are:

3. What kind of kinetic and proxemic affordances does virtual reality technology provide for social interaction?
4. How could these affordances be implied to be utilized in a conceptual virtual reality Obeya application?

These questions are be examined through preliminary knowledge acquired from existing literature and the data acquired through the participatory observation period.

3.1 Data-acquisition

The data for this research was acquired through a participatory observation period inside two social VR platforms: RecRoom and AltspaceVR. The observation period lasted for one month from 4.5.2019-1.6.2019. The observations were made utilizing the VR technology provided by the Turku University. More specifically the HMD devices used were Oculus Rift and HTC Vive. In addition, some observations were made through the PSVR HMD. The goal of the observations was to offer demonstrative data on how the established VR communication is formulized in practice by finding ways how users utilize the kinetic and proxemic cues that VR gives affordance to. The platforms were chosen due to their high levels of activity during the observation periods. These platforms also seemed to have higher amounts of HMD VR users, providing the kind of data on interactions that were intended as the focus of this research. In addition, the platforms focused on activities that encouraged social interaction with both applications having active social spaces where users merely spend time interacting with one another. RecRoom provided as an addition task orientated social interaction, as it offers the users a variety of minigames to play, as well as user created content like virtual museums etc. Other platforms that were assessed at the start of the period include Sansar, High Fidelity, VRChat and Facebook Spaces, but not chosen as platforms for active observation during the period.

In addition to full 6DoF motion-controlled HMD VR users other technologies were involved as due to AltspaceVR mixing users of a variety of technologies together. Therefore, some interactions were observed from technologies like Oculus Go, or even mobile users. While these users had limited capabilities for interaction, their co-presence in the virtual spaces remained the same as they were embodied just like any other user. However, this variety of technologies should be noted to have effect on the overall amount of non-verbal cueing, especially in the case of gestures, as not every user had the chance to move their virtual hands at all.

The nature of this observation research was exploratory as it aimed for an open-minded exploration of the variety of cues that VR would enable people to use in real, non-altered interpersonal interaction. Due to the natural interface the variety of gestures and other interactions cannot be provided through a predefined library of actions, as these gestures are not hard-coded, but created in real time by the users utilizing motion control technology. The observations were executed with little expectations of what exactly should be found. Instead all variety of interactions were recorded in order to cover both expected and unexpected interactions. Because of the unstructured approach the findings here serve merely as a preliminary research as the interactions found should still be validated through further research with an emphasis on quantitative data acquisition. In addition, the main focus was to remain in the kinetic and proxemic cues within the interactions, excluding a huge amount of possible data about chromatics, embodiment, context, paralanguage and other areas of non-verbal communication.

During the observation period the researcher participated actively in the interpersonal interaction. The observations are therefore based on the subjective experience of the researcher and the observations made by them while a part of the interaction. This subjective nature of the data makes it difficult to draw any exhaustive conclusions about social interaction. However, the kinetic and proxemic cues demonstrated are seen as reliable due to the fact that they can be observed by anyone visiting these freely accessible social platforms. The validity of the data is also improved by the non-altered nature of the data. The researcher did not actively declare that an observation study was being conducted, thus ensuring the ingenuity of the interaction. Due to this fact however all personal information on the observed interlocutors is omitted from the presented data, in order to ensure the ethicality of the data-acquisition.

The data acquired revealed a variety of cues within kinetics and proxemics, which was expected. In addition, a variety of more unexpected findings were included, like unsupported cues, third party implied fidelity, amount of uncertainty and miscuing, additional UI elements and issues with locomotion. These findings will be evaluated in order to establish what kind of improvements could social interaction in VR still need and to prompt future research. These findings, as well as the expected findings, will also be reflected upon the more higher-level theories presented in this work. Yet due to the limited

amount of data, the high-level theories cannot be exhaustively explored and will need a vast amount of future research in order to be better understood in the modern VR context.

4 DATA-ANALYSIS AND RESULTS

4.1 Kinetics

A variety of gestures is enabled by the natural interface in VR. These gestures could be observed in a variety of different interactions and therefore need to be categorized accordingly. As established in the literature review different gestures divide into emblems, adaptors and illustrators (Li et al. 2008, Mandal 2014, Krauss et al. 1996, Hans & Hans 2015). The variety of gestures also fulfill certain tasks in interpersonal interaction, such as complementing, regulating, accenting, repeating, contradicting and substituting (Ekman & Friesen 1969). These categorizations will be used here to analyse the variety of non-verbal cues observed within VR in order to establish how well does VR enable the transfer of these gestures from the physical reality to the virtual in regards to the meaning they hold and the support they provide to interpersonal interaction.

Enabling gestures in a communication medium adds another form of communication interlocutors can utilize when interacting through the medium. This additional feature can therefore be seen to make the medium richer, increasing the potential for successful communication by providing more cues, immediate feedback loops, personalization and language variety. (Daft & Lengel 1986).

What is seen especially important is the gesture's ability to engage the other user, thus possibly enhancing the experience of presence through increased involvement (Witmer & Singer 1998) or plausibility illusion by making the interaction more credible (Slater 2009). The increase in presence can be seen as an increase in the allocation of cognitive resources into the exchange at hand through shift in causal priority (Schloerb 1995), which might affect the success of the communication process.

An assumption is made that the gestures use can at points derive their semantic meaning from the user's ability to connect them with their previous knowledge of the use of similar gestures in the real world, thus enabling the user to leverage their existing semantic encyclopaedias. This would imply that the interaction could be experienced as verisimile (Marini et al. 2012). It would also imply a high bandwidth for the transfer of social norms from physical reality to the virtual (Schroeder 2002), providing users more expressive resources in representing themselves appropriately (Miller 1995).

These enhancements in communication could increase the social influence between the interlocutors (Swinth & Blascovich 2006) as their social presence could be seen to increase through the use of gestures. This increase in social influence might enable the creation of social bonds within the communication medium, along with the use of the sociability factors (Holopainen et al. 2018). As already established strong social bonds can be seen as a prerequisite for the use of external information (Gressgård 2010). This

would however require that the interaction is indeed experienced as verisimile, thus inducing plausibility illusion on levels that make the cues impactful and thus socially influential.

4.1.1 Illustrators

Illustrators, or conversational gestures, cover the vast majority of the lexicalization continuum. They are therefore most used in communication and derive their meaning from the context they are used in. (Krauss et al. 1996). In the VR context these gestures were used to communicate affective elements and emotion, to facilitate the social interaction, to clarify messages and to utilize the shared context where the interaction happened. Overall, they seemed to make interaction richer as by providing users an additional form of communication through gestures, thus enabling some of the benefits of media richness (Daft & Lengel 1986). However, the extent to which a user was willing to utilize illustrators seemed to rely on their experience with the technology, or on the technology in use. This would imply lower capability in creating social bonds as it has been connected to the level of confidence the user has with the medium (Holopainen et al. 2018). Due to the novelty of the technology leading to a majority of inexperienced users these gestures did seem scarcer compared to real life, at least according to rough estimate.

In order to further structure the analysis some additional categorization is made based on the perceived use context of different gestures. This categorization will follow the categories given by Ekman & Friesen (1969), dividing the gestures into complementing, accenting, repeating, regulating, contradicting and substituting gestures. From these all but substituting gestures will be analyzed under illustrators. Substituting gestures are placed under emblems instead. Generally complementing gestures could be seen to be used in clarifying the verbal message. Accenting gestures were used in expressing emotion. Repeating gestures mainly engaged other interlocutors. Regulating gestures were used to deal with disagreement more politely, or with emphasis. Contradicting gestures were scarce, possibly due to their high probability to create confusion in an interaction. All these gestures could be seen to better engage listeners and could therefore be beneficial in increasing social presence of interlocutors.

4.1.1.1 Complementing

One way to use gestures is to act out the situation one is talking about through the use of iconic gestures (McNeill 2007). These gestures can be seen as complementing as they reinforce the verbal message (Ekman & Friesen 1969). An iconic gesture can tell a great

deal about the user's attitudes, especially the pace or intensity of the gesture. They also clarify the verbal message by reenacting the described message. Iconic gestures can also be used to engage the other user, which might imply that they can be used in increasing presence through increased involvement (Witmer & Singer 1997), engagement (Schultze 2010), shift in causal priority (Schloerb 1995) or plausibility illusion (Slater 2009).

"A person using a blue version of the robot avatar was telling a story of something/someone and mentioned button pushing. She pushed the air with her hand in the pointing position, which made the message very clear. This gesture could be timed with the speech due to the motion controllers. The user's ability to make her hand into the pointing position without any delay, in real-time with the speech was impressive though. Because of the interface being rather novel I feel that I myself rather often need to think what I want to do with my hands when gesturing, making the gestures more conscious."

Using iconic gestures in this specific way can be engaging to the listener as well as clarifying. Due to the motion-controlled gestures users have the freedom to creatively use these supportive gestures to better communicate. The real-time use of such iconic-gesture would be hard in any other medium. In videoconferencing for example such a gesture could be possible, yet it might lose meaning significantly due to the lack of presence enabled by the shared space. However, a possibly more important notion here might be the difficulty to confidently use these kinds of gestures in real time in VR. As described the iconic gesture observed seemed to be an exception rather than the rule. Having gesturing be conscious due to the novelty of the technology used greatly affects the meaning they convey, as unconscious cues can give rather significantly different information on their user compared to conscious movements (Ottenheimer 2005). The need for experience also creates a threshold for the full utilization of the medium in social interaction.

Deictic gestures are another group of illustrative gestures that could be observed in the VR context. Deictic gestures are used to establish direction, distance or scale of things (McNeill 2007). They can be used similarly to iconic gestures, but with more precise informative content. Rather than merely engaging the listener through descriptive gestures, deictic gestures enrichen the medium by convey rather objective information.

"In addition to the VR technology used, geography offers a rather easy conversation topic as well. We talked about our home countries with another European user. The other user was on an Oculus Go, so they didn't have full 6DoF tracking and therefore gestured rather scarcely. Yet I believe that made me gesture even more. It also made it natural for me to take lead in the conversation. Some of these cues were for example showing measure. Distance is quite natural to show by stretching one's hands. Another is comparison between the level of something, indicating that there is a difference in scale. This kind of way to communicate relativity is quite handy. Pushing something down and lifting another up, showing spots on an imaginary map etc."

While this observation cannot surely validate that the gestures made would have been understood by the listener, it would imply that using these kinds of gestures happens rather easily, given high enough technological hardware. It is argued that the simplicity of the gestures would enable the listener to interpret them correctly. However due to the lack of possibility for any micro movements, details of the interaction might be lost. The lack of details can cause moments of frustration as interlocutors are unable to convey the message they would desire. An interesting note is also the fact that the imbalance in the technologies used seemed to affect the dynamics of the interaction by having the more immersive technology user take lead, at least according to subjective assessment.

Sometimes recognizing people gesturing provided a way to observe a communication situation before entering the interaction. According to Benford et al. (1995) embodiment communicates the activity of other users. The user avatar enables others to receive the various interactions an interlocutor aims to communicate through their natural interface. This activity is visible even when not directly directed to a user themselves, as long as it happens in the space shared with others. The activity of other avatars could even increase the levels of presence as events happening around a user addresses them (Slater 2009). Perceiving such events in a social context seems to be especially engaging (Heeter 1992).

"There was a discussion about some VR device rendering issue or something similar, where multiple users put their hands in front of them parallel to depict two planes/surfaces, as they discussed some technical issue on how the system rendered those surfaces and the issues with that. Relative position of the planes showed through hand gestures, as they showed misalignment and which surface was on top of the other one etc."

Perceiving the activity of others invokes curiosity and makes an approach rather natural. The described deictic gesture seemed to also make it easy for one to approach a technical topic in which one might not have extensive knowledge about. This possibility to communicate through gestures in a more universally understandable way could improve the richness of VR as a communication medium.

Another way to complement communication through the use of illustrators are beating gestures (McNeill 2007). At times the meaning of a gesture is hard to pinpoint specifically as gestures might vary merely due to personal or cultural tendencies. Yet all gestures enrichen, if not directly improve, communication in an avatar enabled VR communication, as they offer potentially meaningful messages to be conveyed. It is also interesting if such gestures are able to increase the transfer of norms, thus increasing the bandwidth of the medium (Schroeder 2002), by enabling culturally characteristic behaviors.

"A very basic gesture is tapping the air with your hand when speaking. I'm not quite sure what that does, but it would seem to either support the tempo of the speaking or to emphasize certain words/syllables. The hand gestures do certainly work contextually as the same gesture usually gets meaning from the content of the talk, being rather neutral

in meaning independently. This is also true with the tapping movement, the ‘speaking with one’s hands’, Italian style.”

Beating gestures are a prime example of gestures that require almost no familiarity with the VR hardware. Simple dynamic gestures that derive their meaning more from the chromatic pacing of the gesture than fine-grained details can be done through simply moving the motion controller. As the semantic encyclopedia for VR communication forms, it will be interesting if the ease of use, and relative ease to understand, makes these kinds of simpler gestures more dominant in VR compared to more complicated cues that might cause ambiguity and uncomfortable misunderstandings.

4.1.1.2 Accenting

Accenting gestures are ones that help the user to emphasize their emotion in a communicational situation (Ekman & Friesen 1969). These gestures can be important in the creation of social bonds, that are incremental for any collaborative tasks between individuals (Gressgård 2010). The expression of emotion can also be seen as an important part in virtual communication where the interlocutors are digitally embodied, due to its ability to make mere avatars seem more human. In the illustrator sub-categories accenting gestures depicting emotional expression often fall under metaphoric gestures (McNeill 2007).

“I visited the Museum of Time in RecRoom. It is a user created space where a large virtual museum exhibits different time periods, like war, dinosaurs and space travel. There were a few other visitors, including a group of users clearly visiting the place together. At the entrance a user spread their hands on the sides in a dramatic manner when saying ‘the museum of time’ in a voice filled with wonder. One of the users in the group approached one of the exhibitions and turned around to look at others when saying ‘It’s the history of war!’ in an excited voice.”

While a big part of the described communication is conveyed through the verbal channel with the use of paralanguage, or tone of voice in this case, it seems clear that the connected gesture supports the communication quite seamlessly. While the same emotional enthusiasm could be conveyed through an audio-based communication channel, the gesture helps direct that emotion in the shared context, thus engaging interlocutors.

Accenting gestures that are used to communicate affective meaning in social interaction (Cristani et al. 2011) can be seen to be utilized in the management of intimacy as well. While the equilibrium theory is managed more through proxemics and by adjusting personal distance or eye contact (Argyle & Dean 1965), gestures are seen to play a role in it as well (Lombard & Ditton 1997). An interesting point is also whether affective

communication is what develops a relationship to bear higher intimacy, thus affecting social bonds between interlocutors.

"There was a gesture from one user in the RecRoom lobby whose discussion I was observing. The user slumped their arms down just like slumping one's shoulders in defeat. With his tone of voice sounding rather lost/desperate/confused the meaning of this gesture was clearly distinguishable."

"A user let out a simple 'Yay!' with hands up. Definitely made the verbal message seem more sincere."

The observed gestures hold more meaning compared to the previous example of accenting, emotion expressing gestures that were more interconnected with a verbal message. In these observations however vocal messages play a more minor role, while a significant amount of information is derived from the illustrator gesture. In the VR environment such gestures can be used to verify the meaning of the verbal message, which otherwise could remain ambiguous due to the possibility of sarcasm for example. As digitalized communication often leaves out a significant amount of micromovements in eyes and facial expressions of the interlocutor, reducing the possibility for miscommunication through clear and meaningful gestures can be seen as rather enrichening for the communication in VR.

4.1.1.3 Repeating

Repeating gestures can be seen to derive less independent meaning from the conversation context and can thus be seen to be used to merely confirm the meaning of the verbal message, at least compared to the other supportive gestures: complementing and accenting. They therefore serve the same task of mitigating miscommunication mentioned previously. This makes the communication medium richer by providing more cues and immediate feedback, while also giving a slight chance for personalization (Daft & Lengel 1986).

"The orange robot user had multiple 'maybe' or 'I don't know' answers that were supported with a slight lift of both hands, palms facing up."

This short observation is rather straight forward and carries quite little ambiguity as the gesture was expressed clearly. One can imagine this not always being the case with such a gesture as shrugs can often be invisible in VR. This is mainly due to the fact that the motion tracking does not include shoulders specifically. Therefore, such a movement can sometimes be seen merely as a slight lift of the hands of the avatar, leaving much space for the specific interpretation of the gesture, mainly created by insufficiencies in the technology.

However generally repeating gestures could be seen to be rather straight forward, leaving little space for misunderstandings. Due to these gestures happening quite quickly and bearing such little extra information besides confirming the verbal message the observations are presented as a summarized note.

"Repeating gestures could be seen to be used most commonly coupled with a greetings or with answers regarding virtual objects. A simple waving motion often reassures that the verbal message is received by the intended user, especially in cluttered spaces with a lot of people speaking simultaneously. It is sometimes rather difficult to locate the speaker despite the lip animations of the avatars. Pointing to an object on the other hand is rather commonly used as it seems to be one of the simplest gestures utilizing the possibility for real-time gesturing and shared context."

If being understood is the norm, misunderstandings are a failure to maintain an appropriate self. Therefore, in situations where information clutter and high levels of activity around interlocutors can cause disruption in the delivery of a mere verbal message, repeating gestures help ensure that the message is received and understood. The observation would imply that locating the sender of a message is sometimes hard, thus increasing the chance for confusion. This issue will be emphasized more with proxemic cues as the group behavior of the users is assessed.

It should also be noted that the repeating gestures presented here are rather clear in their meaning. That is why they can also be used as substituting gestures in order to communicate non-verbally in order to avoid disrupting others in the shared space. This point will be covered in full later as emblem gestures are presented.

4.1.1.4 Regulating and contradicting

Regulatory gestures are used more to facilitate the interaction by affecting turn taking behavior (Poyatos 1983). They can also be used to refuse an invitation or an offer more politely. By putting an emphasis on the verbal message through a gesture one can ensure that the message is well received even while maintaining a level of politeness. In physical reality these gestures can sometimes include touch, or at least in many cases the gesture might rely on the availability to limit another person's actions through physical force. With haptics being almost non-existent and user avatars are completely transparent when it comes to haptics it is interesting to see how the meaning of these gestures convey from the physical reality to the virtual.

When establishing verisimile (Marini et al. 2012) in VR one should note that the level of fidelity provided is often merely implied. In order for the semiosis process to be similar in both the physical and virtual a level of willingness to believe is needed. The experience has to remain coherent, meaning the plausibility illusion should not break in order for the

experience to be given the same level of impact as it would have in physical reality. (Skarbez et al. 2017). Achieving this level of verisimile in social interaction requires high communication skills in addition to the technological features.

"On Recroyale a user asked another user that had just joined my party to join them in a squad with a fist pump and he denied the offer by turning his head and raising his hands. It was very polite. The movement was soft and calm and the message was very clear. I believe this might have also reflected the user's internal cues, his personality in a sense. He was respectful and that gesture and its politeness was heavily supported by his other behavior. He did not swarm us when he wanted to join our team but rather asked politely. It is an interesting interaction since in VR the additional possibility to swarm someone is there due to the lack of haptic feedback and seems quite regular in the Recroom context."

The use of fist pumps as an interface feature in RecRoom is quite interesting. The gesture is utilized when users want to join into a group in order to play one of RecRoom's minigames together. In this particular situation this detail in the interface might have had a rather significant effect to the system's ability to make the regulatory gesture seem more verisimile. As joining into a group would require the invited player to tap the offered fist, the user raising their hands enabled them to rather clearly indicate that they wanted to politely refuse. The recorded effects on the possible recognition of personalization through gestures should also be noted, as the ability to present a distinguishable self is rather important for meaningful interpersonal interaction.

The recreation of semantic processes in the VR environment through the various rhetoric choices can have significant impact, as seen from the previous example. Usually the use of metaphors are visual, as that is the prioritized channel of information in VR (Barricelli et al. 2016). However, providing a vaster variety of such cues in haptic form can be challenging. The previous note gave one example, but usually the VR experience fails to provide the haptics that would enable the semantic meaning of a regulatory gesture to be understood correctly.

"Since movement is tied to hands, gestures coupled with movement are fairly hard if not impossible. This for instance in situations where one would indicate that another person is too close as was witnessed during the observations. In the situation a person raised their hands in front of themselves to shield themselves from the other user that was getting too overwhelming. The loud person pushed through the player's personal place rather intentionally. While the initial hand raising was combined with a slight movement back as the person moved in real life it did not enable the user being intruded to move away from the intruder in an extent that would've seen appropriate."

In this unfortunate situation the lack of haptics made the regulatory gesture fail in carrying the level of urgency the cue was intended to have. In addition, due to the locomotion of the user being tied to their hands, as movement is primarily controlled through the

motion-controllers, the user could not back away from the intruder while doing the gesture. As regulatory gestures can be said to most often happen in situations where another user is denied something, it would be important to deliver them with high fidelity in order to avoid miscommunication. Unfortunately, the VR systems do not automatically provide such affordances, posing quite a relevant design challenge for the developers of VR communication.

Another group of illustrator gestures are contradicting gestures (Ekman & Friesen 1969). These gestures are used to alter the meaning of the verbal message or even completely negate it. Contradicting gestures are most often used in sarcasm and might be prone to causing misunderstandings, as the whole point of the gesture is to create a conflict between the verbal and non-verbal message. Thus contradicting gestures can be difficult to use in newer social encounters and often require quite a rich medium to be used successfully.

"Two experienced users were passing marshmallow sticks to one another. It was quite interesting to observe these two users as they used the interface quite smoothly (locomotion a bit too quickly at times). I believe this might've affected the fact that the users seemed quite confident in the space. They initialized discussions and had no problem interacting even through the motion control enabled communication methods, such as hand gestures. At one point one of them even made a comment while using the 'quotation mark' -gesture. The quotations marks were used very smoothly, which would indicate the user was indeed familiar with the interface. Supported by the tone of voice it was very clear that the hand next to the head clutching its fingers was indeed quotation marks."

These kinds of contradicting gestures were rather scarce in the VR environment, possibly due to another factor present in this note: experience with the interface. There were clearly some users in the social VR platforms that were more accustomed to the interface and therefore were willing to use a larger variety of non-verbal cues, such as contradictory gestures. By nature, contradicting gestures can be seen to have a high possibility for being misunderstood, as sarcasm or other communication where the spoken message is altered towards the opposite can be tricky to understand, especially in a newer relationship. Coupled with what seemed an already existing high level of uncertainty with the non-verbal cueing overall in the VR spaces observed made this category of gestures especially limited.

4.1.2 Emblems

Emblems are gestures that have an agreed upon meaning (Hans & Hans 2015) and are also known as "symbolic gestures" (Krauss et al. 1996). These gestures could be observed in VR in a variety of situations, as they leverage the natural interface by enabling the user

to substitute their verbal messages with gestures. As the users in VR inhabit a shared space with multiple people interacting sometimes in rather close proximity, emblems can provide a way to interact with others without causing an auditory disruption. This shows a great example on how VR can utilize its enhanced richness in facilitating social interaction (Daft & Lengel 1986). However, by adding more information on the visual layer of non-verbal cues these gestures also provide new information for people to decode, thus creating new possibilities to miscommunication as well.

As mentioned in the analysis of repeating gestures are often coupled with rather well-established messages such as greetings or when referring to a virtual object with a pointing gesture. These meanings can therefore be leveraged as stand-alone gestures, making them emblems. For example:

"Turning one's head and waving to people is an easy way to communicate with individuals without striking up a full-on conversation."

"Waving for attention is a regular thing to do, gesturing that one has something to say/show. Happens naturally."

Utilizing such gestures in communication within the virtual space enables one to communicate with others without causing disruption to on-going discussions. These gestures also provide a quick method of communication and might prove even less ambiguous than their verbal counterpart. One example of such interaction can be provided in the grouping behavior context:

"A person joined us, not talking actively. However, I turned my head towards them to acknowledge them. I believe my discussion partner at that moment did so as well. We did it briefly and due to not getting an active response from the person approaching us, we continued our discussion."

This is an example of a situation where a verbal signal is substituted with a gesture, providing less disruption to the already ongoing interaction. Without the shift in eye contact the person might not understand they are recognized. If you compare it to a situation where the head turning would be missing and the recognition would be merely an audio one, thus not clearly directing the cue to the newly approaching person, this cue might not be received as successfully. This might imply that VR also makes it a requirement to actively use non-verbal communication if it is possible. Therefore, leaving a cue out might lead to a misunderstanding.

As embodiment makes users aware of one another they cause some level of co-presence and even social presence. This social presence can then turn into social influence, triggering some level of affective, cognitive and/or behavioral response. (Swinth & Blascovich 2006). However as social interaction in a virtual space might happen between multiple people in a group, one might not always want to maximize their influence but rather minimize it in order for support the interactions of other members of the interaction

group. This kind of behavior can be seen especially important in events with public speakers for example, where the audience is expected not to disturb the event by speaking out of turn. Thus, emblems can be used to enable some level of communication without the disrupting the established norms.

“I attended an event in AltspaceVR for musicians, where people gathered in a rather small space with a couple of sofa arrangements at the back and a microphone in the front. There was also a table with virtual coffee served. The coffee got a few laughs as people tried to break the ice. As the event got more crowded the creator of the event took the stage. At this point most discussions seized and were replaced with silent nods of agreement towards the speaker. There were some attempts for whispering between smaller groups, but as the space was so small these quickly died out as disruptive. The people also rearranged themselves at points through the use of pointing gestures.”

As described the speaker taking the stage changed the norms of the situation to exclude active verbal interaction in the crowd. Yet users were still able to indicate active listening and even manage their relational positions in the space through non-verbal interaction, mainly through the use of emblems. One could add that due to the virtual nature of VR these interactions are not the only ones that would be possible. VR could enable the creation of solutions for situations like these beyond physical reality interaction through features like whispering, where a user would exclude their audio from all but the intended users around them.

Gestures can also be used to express emotion and attitudes (Wang 2009). In proxemics touch is regarded as a defining feature in establishing the closeness of a relationship (Cristani et al. 2011). Therefore, there are a variety of emblems that include physical contact, such as a handshake, a “high five” or a “fist pump”. Even though the haptic feedback for touch is not so extensively present in current VR technology, users still recreate interactions they are accustomed to in physical reality.

“The black clothed player vanished to his own home space, to where we followed him through a portal. We went to the ’living room’ space of his home space and watched Imagine Dragons Youtube videos. I told the host I liked the music. He then approached me and we ‘fist pumped’ to recognize mutual respect.”

This substituting gesture enabled a significant exchange of interpersonal information without the complexity of forming that exchange into words. Enabling such exchange can bear many benefits for interaction as it offers a rich way to convey a message quickly and clearly, as the meaning of emblems are often very well established. It also enables subtle interaction when in a crowded situation that does not disturb others yet is visible to the third party.

The lack of haptic feedback does have rather significant consequence on an exchange that requires direct contact with another person (or their avatar). Even in the “fist pump” example the lack of haptic feedback does reduce the positive impact of the exchange,

making it slightly awkward as expectations are not fully met. This can cause the experience to fail to be coherent, thus breaking plausibility illusion momentarily and disturbing the experience (Skarbez et al. 2017). Yet in other situations this lack of feedback has been taken into account. RecRoom enables haptic feedback through motion controller vibration in specific interactions that are utilized as a natural interface within the game. These interactions include "high fives" and handshakes.

"I was playing one of the dungeon quest co-op games with another user and as we progressed one of us would be taken out by the game villains in various situations. This traversed us into a grey screen and had us wait until the other player would come to us and give us a 'high five'. This gesture was amplified with an audio cue and a haptic feedback into the controller, as well as functioning as the 'revive' button in the game. In addition to this we decided together with the other player to add each other as 'friends' on the RecRoom platform. This happened through a handshake, accompanied with a similar, yet distinguishable audio and haptic feedback as in the high five revive function."

These two situations act as examples on how emblems can be highlighted as interface objects within a VR experience in order to transfer real life norms into social interaction in VR. However, it should also be noted that due to the difference in feedback and the contextual difference of the use of these gestures, one cannot claim that these gestures would bear the same meaning as they do in physical reality. Yet leveraging the familiar semantics in VR seems to have potential in providing a possible way for developing the natural interface elements in VR and enabling new kinds of interaction. It is expectable that at first these interactions might have negative effects for presence in VR due to the slight inability to meet expectations exactly, yet as these features start forming the culture or semantic encyclopedias of VR this negative side effect can be expected to diminish.

Another notion made on the emblems including direct touch with another avatar is that these gestures seem rather rich in the third-party view. This means that while the two people involved directly in the gesture might experience a failure in coherence due to the lack of feedback, people observing this exchange might experience it as if having full fidelity. This notion is important when constructing a virtual space that is verisimile, an experience that is believable (Marini et al. 2012). However, it is a double-edged sword as any implications of fidelity fall away if a user takes the first-person perspective in such an exchange, thus endangering the consistency, and coherence of the experience (Skarbez et al. 2017). An example is provided for elaboration:

"A user entered the campfire in AltspaceVR and was recognized by another user. The two friends then greeted each other by hugging one another. This was interesting to observe as the gesture seemed rather genuine, even though previous experience has many times proved that such direct contact can sometimes feel rather odd without proper feedback for the touch."

The interaction observed is a prime example of verisimile interaction where the virtual exchange between people is experienced as highly believable and plausible. The observation might suggest that there is a possibility in VR for something one might call "implied fidelity" where an interaction is perceived to have more fidelity than it actually has, mainly due to its ability to reconstruct the semantics of the gesture in a way they would be perceived in physical reality.

As noted, the experience of fidelity perceived from the third-party view might however be rather fragile in terms of coherence. The interaction is perceived as verisimile from the third-party only, due to the fact that touch remains irrelevant when the interaction is observed from a far but becomes relevant when in the first-person perspective. Therefore, any increases in presence that the implied fidelity might induce can be seen to be broken if a user partakes in an interaction where the expectations of haptic feedback are not met. This would mean the system has failed to provide a coherent experience. (Skarbez et al. 2017).

"I wanted to talk to a person when there was another discussion going on. Because I did not want to disrupt the discussion, I did not want to draw his attention by talking. Therefore, I instinctively tried to bump his shoulder. I realized only after that of course such a gesture was not possible. However, I believe waving a hand in front of his face or trying to jump around his field of vision were not options either. Therefore, a non-auditive, private "attention draw" was needed, but not available."

This note creates a neat contrast to the previous one and demonstrates how an interaction requiring touch can fail to maintain coherence in the experience. This is also an example on one of the various kinetics that VR does not give affordance to. It is no surprise however, as the lack of micromovements and haptics does affect the possibilities of kinetics in VR quite a bit. In addition, this uncertainty created by the possibility of failure in coherence might have an impact on the user willingness to utilize the established affordances in VR, due to the uncertainty on whether an interaction is possible or not.

4.1.3 Adaptors

Adaptors are a category of rather unconscious movements that users can utilize to vent out internal feelings. The specific meanings of adaptors can be rather difficult to decode, thus placing them on the vague end of the lexicalization continuum (Krauss et al. 1996). In physical reality adaptors often manifest as tapping motions or unconscious fidgeting of a small object like a pen. In VR however, these rather subtle motions were rather invisible, expect in situations where the continuous fidgeting was directed to the buttons on the motion controller.

"A user kept moving back and forth in a rather large area of space as I approached a group. The campfire space was rather empty, so I merely approached these few users there and started chatting about our VR equipment etc. It started to bug me a bit that one of the users, that looked like a vampire with their red eyes and pale face, was constantly moving back and forth. I guess the motion to move around is so tiny with the controller that they were just playing around with it. Yet it made the user seem very restless, as they were moving several meters back and forth in the virtual space."

To imply that the user themselves would be unaware of the motion of their avatar would be rather naïve, yet the motion is still seen as an adaptor that vented out some emotional restlessness the user had. The reasons for this restless state can be speculated endlessly. However, one relevant issue for the design of the VR application would be if this motion was due to the lack of engaging stimuli. As a completely new kind of immersive technology HMD VR devices can surely induce a variety of emotions for users. For some the immersive experience can be overwhelming, yet for others the new kind of visual representation of their most immediate surroundings might cause levels of unrest that they need to deal with, possibly through such actions as described in this observation.

As adaptors are used to vent out the user's internal feelings it might prove to be a possible indicator for the feeling of presence. One depiction of presence implies that the user believes the events happening around them to be meaningful given that the circumstances are reasonable. Thus, the user is constantly evaluating the experience and questioning its coherence. (Skarbez et al. 2017). Presence can also be described as the allocation of attentional resources (Witmer & Singer 1997; Schultze 2010). It has also been indicated that social interaction has rather significant effects on presence (Heeter 1992). Based on these theories it could be possible that the feedback given and received in a social interaction in VR could have significant effects on presence.

"Repeated swaying, seems more like pacing sideways with feet rather than the controller. The orange robot person kept swaying from side to side with their hands hanging in the air in a way that made me think that they might not be holding their controllers. I have seen the similar movement earlier with the so-called vampire guy, but this time I believe it was feet moving rather than controller movement. Both of these communicated a level of uneasiness or restlessness. However, the controller based rapid movements gave an impression that the user was very restless while the swaying was much more subtle."

Compared to the previous note this example provides a much more subtle example of an adaptor. It should be noted that the interpretation of the swaying meaning that the user was indeed shifting their weight from one leg to another might have been mistaken. Yet it is a possible explanation for the side-to-side movement of the observed avatar and could imply the following: some adaptor movements do indeed transfer into VR, if in a slightly changed form. It is rather interesting whether the interpretations of such a movement vary in an immersive experience due to the effects of presence and coherence. If one seems

restless it might give an air of reduced presence or engagement on their behalf and thus might indicate that their attention is partially directed to their physical reality surroundings, thus causing breaks in the plausibility illusion of the other user as well. However, in the light of the given data this is still mere speculation.

The embodiment of the user into an avatar creates the link between the physical reality and the virtual. The avatar connects user motions used into animations of the avatar, thus making them visible for other users. (Schultze 2010). This means that any actions taken in the physical reality rely on the technology's ability to translate them accordingly. This process is rather prone to create uncertainty as the receiver can never truly be sure if they received all the information sent by the sender, or whether a part of the message was lost on the way.

"I observed a conversation between an Oculus Go user and a full 6DoF HMD user. I've learned to distinguish the two quite well, as Go users have one active hand while the other lays motionless on the side. The hand movements of the other user make their technology rather obvious. The oculus go user seemed to hover back and forth constantly. He also turned around periodically. It gave a restless air, just like he would be trying to match the amount of activity the Oculus Rift/HTC Vive user is able to give. Or it might almost be like a head nod, active listening."

This observation highlights the possibility for misinterpretation in VR, which unfortunately is almost always there. Due to the user relying on their activity in the physical reality to transfer into the virtual through the motion tracked devices there is always some amount of uncertainty in interpreting avatar motions as non-verbal cues. This is especially true in adaptor gestures as they are often unconscious and bear little specific meaning. More conscious gestures can be repeated or exaggerated in order to be received successfully, yet for unconscious movements such a possibility doesn't exist, at least in similar manner.

4.2 Proxemics

The immersive qualities of the technology and the feelings of presence, both of self and others, highlights the interactions users have with relational distance and the virtual space. As users were observed a variety of behaviors in the field of proxemics could be witnessed as people organized in relation to each other in the virtual space. Proxemics include the management of personal distance, mutual orientation and grouping (Cristani et al. 2011). Personal distance divides into intimate (<0,45m), personal (0,45-1,2m), social (1,2-3m) and public (>3m), each bearing different meaning for the interaction (Bailenson & Blashovich 2003; Cristani et al. 2011; Hans & Hans 2015) and balancing of the equilibrium of intimacy (Lombard & Ditton 1997; Argyle & Dean 1965; Yee et al.

2007). Mutual orientation is communicated mainly through eye-contact and body orientation (Cristani et al. 2011). Grouping is guided by the human territoriality (Hans & Hans 2015) and is established through a variety of F-formations (Cristani et al. 2011). In addition to these aspects, locomotion was seen an important factor in the upkeeping of attention, management of mutual orientation and handling of relative distances.

In the immersive virtual space proxemics are enabled by user embodiment (Benford et al. 1995). Embodiment works as the link between the motion-controlled user interface and the virtual world and other users within it (Schultze 2010). Being represented by an avatar the user can directly control co-presence between the inhabitants of the virtual space is enabled, which in turn can be transformed into social influence (Swinth & Blascovich 2006). The influence towards other users conveyed by merely being present in the same space is mainly facilitated through proxemics.

The non-verbal communication enabled through proxemics can again be seen to make the communication medium richer, enabling more cues, immediate feedback loops, personalization and language variety (Daft & Lengel 1986). As the effects of the proximity of other users avatars have been validated to bear similar meaning as in physical reality regarding proxemics (Dzardanova 2017; Bailenson & Blascovich 2003), proxemics can be seen to be another way to increase the bandwidth of the system in the transfer of social norms (Schroeder 2002). The mission of maintaining an appropriate self (Miller 1995) is rather directly supported by enabling users to have more tools in the management of intimacy and equilibrium (Argyle & Dean 1965; Lombard & Ditton 1997; Yee et al. 2007).

4.2.1 Personal spaces

Personal distance in VR applications is rather different than in reality, even though the personal spaces are validated to be recognized in virtual spaces (Bailenson & Blaschovich 2003). AltspaceVR and RecRoom both offer their users the chance to activate a "personal space bubble" which makes other users vanish from view if they enter a set distance (usually intimate zone, <0,45m). In addition to this the virtual avatars lack haptics almost completely and are immaterial, meaning one cannot collide with another's avatar. This could be seen to make interaction with relative distance and personal space less strict in VR in a variety of situations.

"We were talking about the show Overlord with a user in AltspaceVR and he was moving his hand rather actively as he was speaking, which is rarer with Oculus Go users. The motion was a half circle from his side to in front, upward (clockwise?) and back. During the discussion he also came too close to me, vanishing from my view as he entered my personal space bubble. He apologized after becoming invisible, which would indicate

he recognized the action to be quite intrusive. I did feel the need to move, as I lost vision of my conversational counterpart."

Whether the observed apologize was indeed due to intrusion of personal space or merely due to the unfortunate event of losing one's discussion partner, it was nevertheless noticeable by both parties. The constant motion recorded could indicate that the reason for this intrusion was a simple mistake on the other user's part, as they might've been acting restless (based on the adaptor gesture recorded) and miss-clicked the movement by accident. This kind of user inexperience in managing the teleportation-based locomotion seemed to cause trouble in interaction with relative space rather often, as will later be further established. However, at this point the most important conclusion is to note that the researcher felt the need for readjusting their position mainly due to losing track of their conversational counterpart, not so much due to strong feelings of shift in the equilibrium of intimacy. This might indicate that the lack of touch and collision could lessen the levels of intimacy in social interaction in VR.

Another example of similar behavior can be seen here:

"A player was playing the xylophone and another rudely teleported to his face to play it. He then stated that the newcomer was "awkwardly close." He then moved away."

These findings seem to question the importance of the personal spaces that Bailenson & Blasovich (2003) established to exist in immersive virtual spaces. While the reactions recorded seem to enforce the fact that the personal spaces exist, the repercussions for intimacy seem to be highly different. The reaction of anxiety, that Argyle & Dean (1965) mentioned to be the response for inappropriately high intimacy, can be witnessed clearly. Yet the counter action could be seen to measure more towards one imagined for an intrusion in the outer personal zone in physical reality, rather than a full break in the intimate zone. This difference in how dire the intrusion is experienced might trace back to the lack of haptic feedback in VR.

When analyzing proxemics, one needs to take into account both conscious/unconscious (Ottenheimer 2005) and intentional/unintentional (Pavlovic et al. 1997) cues. As embodiment makes users present to one another it also communicates the change in the proximity of other users (Benford et al. 1995). This enables the feeling of co-presence which expands into social presence if users engage in social interaction (Swinth & Blascovich 2006). As mere presence in the shared space imposes the dynamics of relational distance and proxemics to the VR users they can be expected to react to those changes.

"People started dancing, pumping their hands up and down, as well as their head. This happened when a person came with a stereo to us. This non-verbal reaction made it clear that the person was recognized, and their activity was approved as people joined in and behaved accordingly."

"On the other hand, before this event a player approached a couple of other players tuning their options. Even thou the approaching player came close the other players did

not get bothered and did not react to his presence. Therefore, they did not compliment the expected social cue waited for and therefore non-verbally refused the approach."

While the first example is in no way regulating, it gives a contrast to the second one. Due to a level of co-presence and social presence in the environment the proximity of other people needs to be recognized, or otherwise the lack of recognition can be understood as a regulatory cue. This would imply a constant level of social presence induced by the active avatars within a social VR space. It can also be compared to setting a status on a text-based communication medium where a user can be "available", "busy" or "offline". The status stated affects expectations on social interaction.

In a more summarizing note personal space intrusions and crowding could be seen as rather common in the observed social VR platforms, especially RecRoom where the userbase is younger. As people move around in the space, often quite quickly as the majority of users utilize teleportation as their preferred form of locomotion, it is rather common for a person to intrude one's personal space or an F-formation one might have with a discussion partner. These disruptions are usually brief and therefore a minor annoyance. Yet they can easily be established to have quite apparent effect on the rapport or momentum of a discussion, thus negatively affecting communication. Readjusting to such an encounter is hard due to movement relying quite heavily on the interface. This matter of the effects that locomotion has on personal space and proxemic cues is evaluated next.

4.2.2 Locomotion

An important aspect of proxemics was highlighted especially in the observation period as the researcher assessed the dynamics of adjusting personal space. Adjustments in space are naturally made through movement. In physical reality the non-verbal information that movement gives can be seen tied to posture, chromatics and the change in equilibrium of intimacy between individuals. A defining element in physical movement however is that that movement follows the laws of physics. In the case of virtual spaces on the other hand the laws of physics are defined by the system, which quite completely transforms the meaning that movement conveys, in non-verbal communication sense. In both RecRoom and AltspaceVR locomotion was enabled through teleportation, or through "natural movement" where the user levitates forward seamlessly. The action of movement is controlled through the motion controller, held in the user's hand. In case of teleportation the movement is controlled by pointing the controller and pushing the button assigned for that action. The user is shown a teleportation marker that indicates where they will land. The user then releases the button and shifts their position. In seamless movement the button push merely shifts the user in the direction the motion controller (or HMD device on their head depending on options) is pointing towards.

As locomotion done in such a novel way in VR, especially given that the whole technology is not exactly in broad use yet, experience with the interface can significantly affect a user's ability to shift their position in the virtual space. As with gestures this difference in experience is often most visible through how active users are with moving around in the space.

"One of the more experienced users kept dashing around the space in a pace that was hard to follow. As they moved through the 50-100 meter space in half a second it was quite hard to follow. At times this rapid movement brought him behind me and the only way I kept track was hearing his voice suddenly behind me. At other points there was a several second delay, as I needed to look around to figure out where he vanished to."

It is easy to imagine how hard it is to keep track of a user, given that no animations are given about their movement. A user merely vanishes and appears in another location. This way of locomotion is often preferred in VR due to more seamless movement being prone to induce cybersickness and nausea. Yet from a communication perspective the constant dashing is hard to keep track of and can make the environment feel frantic. In AltspaceVR and Recroom both the only option to tracking people besides searching them visually is the spatial audio which, given the right audio output, does give some chance of detecting moving players in the space even without direct visual contact. Yet these options can be seen as rather insufficient.

As mentioned so called regular movement in VR is rather scarce due to the tendency of the technology to induce motion sickness or the feeling of nausea. One should note that even this movement does not offer naturalness in posture, as this locomotion alternative merely makes the avatars hover with a fixed speed to the direction of the user's choosing. No animation for legs is given, although this may vary depending on the application. Some possible benefits could still be possible to be gained in social interaction given this version of movement.

"Regularly moving people give a lot clearer point of direction and thus also have a more natural speed for their proximity changes. Teleportation makes changes quick and frantic, especially when you are facing a person and they suddenly vanish from your field of view. Therefore, steady movement might be preferred in social interaction, since it gives more information on the transformation of one's position."

Transformation of location can be seen the main proxemic cue locomotion can give when posture cues are excluded. Thus being able to observe the change would bear apparent benefits. This method of movement could even lessen the reported disturbances in personal space. As mentioned before these disturbances are quite common, whether due to inexperience with the interface or mere ignorance of the more intimate personal zones due to the lack of haptic feedback. It should also be noted that due to the style of movement (teleportation) being tied to one's hand (motion-controller) the adjustment of positioning in personal space intrusions is quite counterintuitive.

A more extensive report on the challenges with locomotion is presented next:

"While exploring the 'Ori amusement park' environment in AltspaceVR with another user I noticed there are many issues with positioning in relation to another user and keeping track of their movement and location. As we moved around the area and our attention moved from one another to the world and back there were many situations where the other person was not located in the place they previously were. Even if a person is standing right next to you, there is no way of knowing that if they don't stand in your field of vision. And what is completely flipped is the fact that if the person gets too close, they vanish. Therefore, rather than having more sensory information from them, you lose what you already had. Even spatial audio doesn't help you locate a user if they are too close to you, as it is not accurate enough."

"We ran over the edge of the amusement park with the other user and noticed floating cars, virtual towers and animals around the main island. We also looked at the surrounding artwork that was in the horizon. Due to not having any land beneath us and at times moving very far away from the other game objects, it was hard to measure distance. Therefore, there were many situations where we drifted outside of each other's audio 'proximity', out of range for the other to hear. Therefore, there were multiple situations where we turned our heads looking for the other and asked loudly 'where are you?' followed by a 'there you are' when the other user was located. This was much due to teleporting and little feedback on the other player's movement, as there is not any audio or haptic feedback. The teleportation is also such a quick method of movement that the other person moves outside of audio range in an instant. This lack of feedback is hard to adapt to as it would require a rather unusual discourse on tracking the other players movement and location through verbal communication constantly."

This observation would imply that the personal bubble is sometimes even counterproductive as it can make an interlocutor vanish completely during mere rearranging of one's relative positioning. Spatial audio on the other hand does not seem to provide an adequate method for facilitating interpersonal distances, especially in a dynamic interaction. When users are on the move actively, constantly shifting place, additional elements seem to be required in order to enable more successful interaction.

4.2.3 Grouping

The tendency to organize into groups in physical reality seems to transfer into VR. This behavior was described through the F-formations (Cristani et al. 2011) or through territorial behavior (Hans & Hans 2015). When describing how people organize to facilitate the social interaction one needs to take into account that in VR orientating in relation to others

means orientating in relation to the avatars that represent them. The graphical representations make users present for one another (Taylor 2002) and thus enable co-presence and social presence within the space (Swinth & Blascovich 2006). These features are highlighted in grouping behavior especially, as a key component in group interaction is shifting attention from one to another in order to either recognize a new member into the group, to facilitate turn taking behavior or in order to create distinction from other members in the same virtual space.

Virtual spaces create quite a unique digital communication context as there can be dozens of users inhabiting a social space at one time, all communicating through the same medium. While organizing social interaction to this extent through a 2D medium could easily create information clutter and thus negatively impact interaction, in VR this problem is all but completely negated as the 3D space enables distributing that information in a way that does not overwhelm a user (Bowman & McMahan 2007). However, this does require a level of initiative from the users in that space in the forming of grouping behavior. As defined by Cristani et al. (2011) an F-formation is created when the members in it separate an area to which they have direct, equal and exclusive access. An example of the creation of such an area is given:

"There was also a group of artistically dressed avatars grouped up (artistic meaning a beret and a tad fancier clothing). These groups are quite frequent and usually give a very unique air to them. They seem to represent their own culture which seems hard to approach if you are not part of those individuals. This is mostly indicated by the high threshold of presence needed to be given to these kinds of groups before getting a response. This time a remark on the topic being discussed at the moment (which was musical instruments) was a way to get their attention and join the discussion briefly. Yet due to lack of eye contact and no change in the circle positioning there was no indication that I would've been taken in as a full member of the discussion."

While the lack of haptics and the ability to walk through other users would give anyone the ability to force their way into a group rather easily, such behavior is frowned upon similarly than in physical reality. Therefore, a distinctive group like the one described above gets to enjoy their exclusive area, at least regarding the presence of avatars not included in the group. However due to the spatial audio and the underlining possibility for anyone to intrude the area the group has established to be their own, the group is not entirely excluded from the virtual space when it comes to presence, but rather they are merely otherwise occupied. This could be seen as the VR version of chat status indication, where text-based mediums might use tags in order for users to establish if they are offline, busy or available.

Similarly to the relation with personal distance and locomotion, grouping behaviours also suffer from users not fully knowing how to micromanage their movement, thus creating uncomfortable situations in the interaction space. The F-formations formed seem to

thus fulfil their role in transferring social norms into the virtual space, indicating higher bandwidth for the system (Schroeder 2002) while not offering quite identical interaction in relation to the groups formed. Breaking into a group's territory seems to induce feelings of failure in presenting an appropriate self, which should induce feelings of embarrassment (Miller 1995).

"Teleport precision is not always right on place. I've had a hard time at points to pinpoint my location precisely when I'm on top of objects or even in a discussion circle. It is hard to therefore position with the teleportation and I've felt rather embarrassed at times when I mistakenly teleported too close to someone or in the middle of the circle, merely because I did not really land to the spot the teleportation indicator showed."

The described observation is not the only one of such an encounter as this inability to accurately move within the space is rather common in VR platforms. The intrusion is therefore often not voluntary, but merely a form of inexperience with the interface, or possibly even a fault in the technology if the mistake is due to the teleportation indicator failing to accurately show the user where they will land. Whatever the case one can expect these kinds of situations in failing to behave according to norms to cause the users to be careful with the way they interact in the space, making movement more conscious and therefore having possibly significant effects on user willingness to utilize the affordances in hand. Similar observation was made with gestures where the amount of activity was seen to be scarcer than in physical reality, possibly due to the amount of conscious effort interactions take or due to the high possibility for miscommunication.

While there are obviously some challenges in utilizing proxemic cues in VR the various possibilities for leveraging those cues also provide great potential for the facilitation of social interaction. By establishing mutual orientation through positioning, body orientation and eye-contact (Cristani et al. 2011) users are able to non-verbally guide the interaction, thus making the whole exchange richer. By utilizing shifts in eye-contact users are able to communicate the direction of their attention (Hans & Hans 2015; Argyle & Dean 1965). Just like regulatory gestures, proxemics can be used to manage in turn-taking behavior (Poyatos 1983). This regulatory behavior is rather naturally connected to the whole concept or F-formation groups, as one of the main functions of the formations is to regulate access to an area or interaction (Cristani et al. 2011). An example of such behavior is given next:

"I was observing two users that I had previously chatted with myself in order to better get an objective view on the cues they used. One of them were using a male avatar and the other, presumably female based on their voice, was represented as a blue robot. A new user then entered the space, first approached me and then the two users I was observing. The person moved close to the two users discussing with one another and said 'hey!' in order to get their attention. The male user first moved closer to the robot user and it

seemed like the duo was not ready to attend to this new interruption. This made the approaching user be silent for a bit before trying again with a 'hey, excuse me' which got a reaction and initialized a discussion between the three. The new user therefore seemed to be required to hover for a while before being given access to be a part of the group."

The described process gives rather meaningful insight on the various ways VR enables users to communicate to one another through non-verbal communication. Initially it should be noted that the initial vocal attempt to join the group did initialize an instant reaction from the duo already grouped. The male user rearranged the formation in order to signal the newcomer that the approach was recognized, yet by using a proxemic cue rather than a verbal one, the ongoing discussion between the users remained undisrupted. After waiting for a while, still present and thus indicating a persistent desire to join the conversation, the new user was able to repeat the verbal cue for joining and got a more preferable reaction by being invited as a part of the discussion. This might indicate that the variety of tools VR provides users through the non-verbal communication affordances creates a larger variety of weight one can put on their messages. This enables more flexibility to communication as a requirement to interact with a new user does not need to disrupt the on-going interaction.

One rather significant benefit that enabling grouping behavior in VR might provide is the effects on the creation of social bonds and increasing social influence. As established social bonds can be seen as a prerequisite for the use of external information (Gressgård 2010). These bonds could possibly be created by utilizing social presence, which can be increased through active collaboration between people co-present in a virtual space. Increased social presence is seen to positively affect social influence. (Swinth & Blascovich 2006). Even though prove for direct benefits of presence in task performance is yet to be indicated (Ellis 1996) the possibilities for better collaboration might still persist. An example of a potential situation for such interaction is presented here from a collaborative mini game in the RecRoom environment:

"Within teams interaction in RecRoyale was based on huddling up in the pre-game bus and discussing where to go. The map worked as a shared viewpoint. The situation resembled well the real-life situation of sharing a map and naming places in it. I noticed however that I was missing the pointing feature in the game as it was hard to lean in to see where the other player was looking in their map and precisely point my suggestion there. Therefore, I believe a 2D desktop pinging that gives players indication on where everyone wants to go works more efficiently from the task orientation point of view, as locations are pinged and marked in a single, shared map. However, the pre-game communication in VR might've stirred deeper collaboration due to the gathering round effect. People were not communicating from a distance, but because of the spatial audio feature needed to come closer to one another and therefore create their own space separate from the other groups, therefore indicating that we were a team."

To give this observation further context, RecRoyale is RecRoom's VR battle royale, where players jump out of a flying bus into a vast scenery, which they then navigate to find equipment and battle other players. The game thus actively pushes users to collaborate in order to perform better in the given task. The observation given does support the claim that this task would not be significantly better tackled through the mere social presence of the users as 2D options for the navigation task are seen preferable. Yet the note also implies that there was an increase in collaboration between the users due to the possibilities of the shared virtual space. What seems most apparent is that the players were able to group effectively within the space, thus creating a sense of a team by utilizing F-formations.

The immersive qualities of the VR technology can be seen to provide potential for the avoidance of information clutter (Bowman & McMahan 2007). Compared to a 2D display video conference or chat-room social VR applications do indeed provide the users the possibility to arrange in the space in a more flexible manner, often in groups facilitated by the F-formations. However, some situations were recorded where the users were not able to utilize this potential available to them.

"It would seem that in larger groups people would need to actively wave their hands in order to make sure them talking, or having something to say, would be recognized. Spatial audio does not seem enough for spotting who is talking. However, these kinds of hand gestures seem rather rare. This problem of recognizing who is speaking is quite a common one in VR discussion circles when multiple people are talking at once. The animated activity cues, moving lips and flashing lights on robot avatars become hard to track. Especially difficult is identifying who exactly is speaking, as it is hard to connect audio with visual cues. This is mostly a problem in larger group dynamics, not so much in 101 discussions."

Whether due to the lack of fidelity and detail in the non-verbal cues or merely the poor quality of the audio feedback it seems that these VR applications still might need improvements to successfully enable seamless social interaction between individuals in larger groups in the virtual space. It is interesting to note that while this problem of recognizing the speaker was apparent, the possible tools the affordances available could provide were not utilized. If a VR user notices that their messages are not correctly received, they have the chance to use gestures to provide additional information for the interlocutors to indicate the importance of them being heard. However, this kind of behavior might be radically different to what would be expected in such a situation. In physical reality there would be more possibilities for more subtle cues such as eye-contact, facial expressions and change in posture to indicate a user was not heard. The affordances VR provides can be experienced as much more visible, apparent or drastic. Therefore, it seems that instead of utilizing the possible gestures available, that might intervene with the user's perception on what would be appropriate in such a situation based on their experience on

similar situations in physical reality, the user merely decides to not act on the fact that they were not heard.

5 CONCLUSIONS

While the initial approach of VR establishing social interaction more towards that of face-to-face communication cannot be exhaustively validated based on the analysis presented in this work, some relevant conclusions for the argument can be made. The data presented did not contradict the various literature on presence, but rather offered supportive findings towards the existence of social presence in interpersonal communication in VR. This statement was demonstrated by the fact that clear behavioral changes were recorded that were initialized through the use of non-verbal cues within the social VR platforms. This would indicate clear social influence between interlocutors and thus confirm VR having some potential as a communication medium. However due to the lack of comparison with other digital mediums no finite conclusions on the relative position of VR as a communication medium can be made.

Another factor that remains quite ambiguous is VR's ability to provide verisimile interaction. While some behaviors could be observed to be present similarly in VR that they appear in physical reality, such as grouping behavior and personal distance as well as various gestures, many of these interactions also varied. For example, the lack of haptic feedback was seen as an important factor in changing how interaction could be perceived and what kind of impact did it have. Thus the extent of social norms transferred remains vague, while the ability to utilize existing semantic encyclopedias seems rather apparent based on the data analyzed.

These changes on perception of interaction might have had effects on the plausibility of the whole experience. In general, it was reported that the amount of gesturing seemed lesser than one would expect in physical reality. The reason for this can merely be speculated here but two possible reasons for it were mentioned even within these works: plausibility illusion and confidence with the interface. The explanation proposed here is that the lack of active cueing might be due to the lack of perceived impact the cues would have, thus indicating low plausibility illusion. It would be logical that a user that feels their actions will not have the impact intended is discouraged to utilize those actions. Given the rather high levels of uncertainty observed in the overall interaction in the social VR spaces, which are proposed to be caused by the novelty of the whole experience and the technology in use, the discouragement of the user can be seen defining to the willingness to utilize the given communication medium. Another explanation for the low level of interaction could be the lack of confidence with the medium. Both of these propositions should however be further researched in order to better understand the phenomenon of social interaction in VR.

5.1 Implied fidelity

As a synthesis of the approach chosen for the creation of VR communication through verisimile interaction that induces plausibility illusion the term implied fidelity is proposed. This term is offered as a possible explanation on the ability of VR to provide better communication through the use of richness, transfer of social norms, social presence and the overall effects these have on social influence. The term also connects the created virtual space with the prior knowledge of the user. Implied fidelity can be defined as: "the transfer of contextual semantics into virtual objects, interactions or events that the user can imply to have similar meaning as their physical reality equivalents." The main idea is that in order to build verisimile experiences that enable high plausibility illusion and therefore high impact, there is a need to be able to leverage the existing semantic encyclopedias the user has. As the goal is not to recreate the physical in the virtual in full fidelity it needs to be ensured that the user still implies that what is presented to them has similar meaning, and thus impact, as the physical reality equivalent.

Implied fidelity thus works as a bridge between verisimile design of VR communication that leverages prior knowledge such as social norms, and presence in VR, especially in the social setting. By enabling the user to imply that the illusion they are presented with bears similar meaning to those already familiar semantic constructions the user has, it is easier to draw their attention to the virtual events, thus increasing presence and enabling plausibility illusion. In a social setting the implied meanings given to the events and interactions can be seen to translate to social presence and therefore affect the social influence. Literature would imply that this is highly possible in the social setting, as people tend to have less problems interpreting others to be real even in the virtual, thus making it easier to give higher impact to the interaction between people.

However, as demonstrated in the observations with the third-party implied fidelity and the interaction regarding touch that followed that note, implied fidelity relies heavily on the coherence of the experience. As users imply the virtual to have similar semantic meaning to that of the physical reality, they might also start to expect the virtual to work more according to the laws of the physical reality. These expectations are prone to not be met as the implications made fail to exist. Therefore, the design of verisimile experiences in VR should give special attention to the user's habit to actively question the virtual experience and test the limits of the illusion provided.

As times goes on and the VR technology matures the leveraging of physical reality semantic encyclopedias might become less important in the creation of verisimile interaction in VR. This is mainly due to the fact that VR is expected to create semantic encyclopedias of its own, thus replacing the process of reflecting virtual events to prior knowledge based on physical experience, and instead utilizing the already cumulated

knowledge of VR experiences. Therefore, the whole approach of utilizing verisimile design and implied fidelity to induce presence and plausibility might be short lived. However, while the technology is still novel and VR specific expertise is scarce, basing user experience to the semantic recreation of the physical reality could provide a prominent approach for VR design.

5.2 VR Obeya

Obeya is the management tool created for the development of production systems. The traditional version of Obeya collects both key information and key personnel into a shared space to make decision making and action taking quicker and leaner. The benefits of Obeya seem apparent in maximizing the value created. However, in order to leverage the development in information systems and to enable Obeya to be used remotely digital versions of the tool have been created. However, these tools limit the possibilities of collaboration as remote members can communicate through 2D mediums only, such as text, audio or video-based solutions. VR and the affordances it provides to social interaction might therefore be used to create a virtual version of the management tool that can leverage the modern IT systems as well as maintaining higher capabilities for collaboration. The conceptual VR Obeya presented next might enable the same experience of collaboration in a shared space due to the levels of presence the immersive technology provides.

Creating an application for Obeya in VR could expand some of the features of the digitalized Obeya by introducing spatial audio between users, 3D spatial visualization and natural interface for interpersonal interaction. VR could also enable the mobile/remote work benefits, or rather solve the same problems that remote work poses to physical Obeya, while maintaining more of the spatial benefits of collaboration that the physical Obeya offers. VR's potential could provide real time remote collaboration with adequate richness, instead of dialing down the digital experience into 2D screens scrammed with information and collaborators. VR headsets could even make all the technology needed to create the space for virtual Obeyas abundant, as having multiple screens is not necessary when the various data management applications can be projected directly to the VR space as floating screens. The novel technology would therefore impose no great expenses on hardware compared to the extensive amounts that digitalized virtual Obeyas would require.

Implementing Obeya in VR could therefore be expected to provide a number of benefits like reducing information clutter, utilizing human proweness for 3D pattern recognition and most importantly enhancing digital collaboration more to towards the level of face-to-face collaboration. By enabling the users to immerse themselves in a shared virtual space they are enabled to share information without the limitations on view that a 2D

display based virtual Obeya would impose. In the future the 3D visualization benefits that the immersive medium and the natural interface pose could be utilized to improve on the visualization even further. Yet within this work the focus will be on the immediate benefits VR presents for interpersonal communication within the virtual Obeya in order to enhance the collaboration aspect of virtual Obeya closer to the level of the traditional, physical reality Obeya.

The biggest advantage VR has compared to other communication mediums is that due to the immersive qualities and the presence that enables, communication participants are able to feel that they are in actual proximity of one another. This element of social presence is what enhances the visual, kinesics and audio cues provided by VR above the level of that provided by for example video conferencing where all these elements are present but on a 2D screen. Due to this advantage and its effects on social influence VR is already being used in various communication fields such as marketing and training, in addition to the actual social applications like AltspaceVR, Recroom, Facebook Spaces and others.

The simplest way to imagine the VR Obeya IT infrastructure is to have users on their own devices (HMDs) connected to the VR instance powered by an external server, which is also connected to the data bases needed. Therefore, the infrastructure components would be the user devices, the VR server and the database server(s). The various widgets and business applications needed could be projected into VR as floating screens in order to enable visualization alike in physical Obeya. Support for the manipulation of the information though the novel natural interface (motion tracked controllers) would be the most extensive addition in the VR Obeya compared to the virtual Obeya. However, details on the technical details of the VR application are at this point irrelevant, focus being on the VR session and the benefits for interpersonal interaction it provides. While the impact these choices have on the VR session is recognised, these qualities are seen as context reliant and will therefore not be specified in more detail.

5.2.1 What do the observed affordances offer a VR Obeya?

While the observations on the affordances for non-verbal communication were made in a rather different context from that of an Obeya, the demonstrative effect should remain relevant. Due to the technology remaining the same the cues observed can be seen to transfer from the social platforms to the conceptualized collaboration platform. The meaning of the actions will surely vary, yet the affordances will stay the same. Therefore a summary on some of the findings of the data-analysis are presented to estimate what kind of benefits VR could provide the Obeya management tool.

As established in the data-analysis VR and the natural user interface enable a variety of ways for users to create richer and possibly better interpersonal interaction. The kinetic

and proxemic cues can be used to support and facilitate interaction, to utilize the shared context in building shared points of reference, to express emotion and possibly enable enhanced building of social bonds through the digitally enabled interaction. Overall it seems that there are benefits that the extensions to the non-verbal communication could provide to social influence, yet these benefits are still overshadowed by the fact that users seem to lack confidence with the medium to be able to leverage it, or their prior knowledge, during interaction. This is seen to affect the exchange negatively by affecting the impact of the interaction, possibly tracking back into the plausibility illusion and coherence the experience is able to induce.

To cover the various additions VR offers collaboration in VR Obeya some of the findings will be highlighted. For example, deictic gestures can be utilized in VR Obeya to help collaborators navigate the information presented by pointing and other possible gestures. Regulatory gestures on the other hand can be leveraged in situations where there are possible disagreements about the information being discussed, providing collaborators a way to clarify their disagreement politely without overly emphasizing it verbally. The additional UI elements that are possible to be added for the VR Obeya specifically in order to further improve collaborators' ability to utilize the technology in interaction with the external knowledge provided. However, a note should be made that these UI elements should be designed to not disturb the on-going social interaction, as UI elements invisible to other users can create a level of uncertainty and unnecessary ambiguity into the social interaction.

Proxemics and emblems can be used to facilitate interaction in groups through adjustments in relative distance, possibly guided through silent gestures that do not disrupt ongoing interaction. The grouping behavior and distances can also be used to establish levels of intimacy within the collaboration, possibly reflecting the success in creation of rapport within the interaction. Additional channels provided for the expression of self are accenting gestures that can be used to better establish emotion. Additionally, adaptors can unconsciously reflect collaborators' attitudes towards the work at hand.

Possibly the biggest advantage these improvements in social interaction provide is increased engagement. By enabling more information to be conveyed the collaborators can be expected to be more present in the exchange. In general, many gestures and proxemic adjustments are used to activate interlocutors in order to better prepare them for receiving verbal information. This would also support the claims in literature that highlight the effect of social interaction regarding presence. In VR Obeya this element could be seen to better duplicate the feature of physical, traditional Obeyas gathering key members around to solve issues at hand in real time through very active collaboration. By enabling fully synchronous collaboration in VR the benefits of rapid decision making can be expected to be supported, while still enabling the benefits of a digital medium for remote collaboration.

5.3 Limitations and future research

While there are potential benefits that VR offers for social interaction such as the collaboration in a VR Obeya, the data gathered here cannot be seen enough to thoroughly validate these findings with academic robustness. With the subjectivity of the participatory observation and the lack of quantitative approaches the various findings can be significantly improved by analyzing them with a variety of other methodologies. Therefore, further research is prompted. This need for further knowledge on the intricacies of VR communication is highlighted by the various critical acclaims one can still make regarding the social interaction in VR.

VR as a communication medium is still lacking in various important elements of communication. While emotion can be reflected through gestures, they cannot be read from one's facial expressions. The lack of touch deprives the collaborators of various possibilities for interaction. Locomotion can be challenging, especially when needed as a reflex. Interaction within VR is often more conscious, thus driving it further away from the fidelity of reality and the face-to-face communication one is already so accustomed with. While the whole physical reality does not need to be recreated in virtual to establish verisimile interaction that would transfer norms and enable leveraging of our semantic encyclopedias, there are still some key features that need to be added to make VR communication reach its full potential as a digital communication medium.

Therefore, extensive research is still needed before VR can be properly as a digital communication medium that could be comparable with the existing options of text, audio and video-based communication. This definition would help the application of VR in both business and entertainment as clearly defined benefits and features would aid in managing the risks and uncertainties of utilizing such a novel technology. The potential has been described here through the concepts of verisimile interaction enabling full plausibility illusion in the user. However, the ideal user experience is significantly easier to form in theory than it is to create through practical solutions.

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7 APPENDIX

Reported observations based on the recorded field notes:

"A person using a blue version of the robot avatar was telling a story of something/someone and mentioned button pushing. She pushed the air with her hand in the pointing position, which made the message very clear. This gesture could be timed with the speech due to the motion controllers. The user's ability to make her hand into the pointing position without any delay, in real-time with the speech was impressive though. Because of the interface being rather novel I feel that I myself rather often need to think what I want to do with my hands when gesturing, making the gestures more conscious."

"In addition to the VR technology used, geography offers a rather easy conversation topic as well. We talked about our home countries with another European user. The other user was on an Oculus Go, so they didn't have full 6DoF tracking and therefore gestured rather scarcely. Yet I believe that made me gesture even more. It also made it natural for me to take lead in the conversation. Some of these cues were for example showing measure. Distance is quite natural to show by stretching one's hands. Another is comparison between the level of something, indicating that there is a difference in scale. This kind of way to communicate relativity is quite handy. Pushing something down and lifting another up, showing spots on an imaginary map etc."

"There was a discussion about some VR device rendering issue or something similar, where multiple users put their hands in front of them parallel to depict two planes/surfaces, as they discussed some technical issue on how the system rendered those surfaces and the issues with that. Relative position of the planes showed through hand gestures, as they showed misalignment and which surface was on top of the other one etc."

"A very basic gesture is tapping the air with your hand when speaking. I'm not quite sure what that does, but it would seem to either support the tempo of the speaking or to emphasize certain words/syllables. The hand gestures do certainly work contextually as the same gesture usually gets meaning from the content of the talk, being rather neutral in meaning independently. This is also true with the tapping movement, the 'speaking with one's hands', Italian style."

"I visited the Museum of Time in RecRoom. It is a user created space where a large virtual museum exhibits different time periods, like war, dinosaurs and space travel. There were a few other visitors, including a group of users clearly visiting the place together. At the entrance a user spread their hands on the sides in a dramatic manner when saying 'the

museum of time' in a voice filled with wonder. One of the users in the group approached one of the exhibitions and turned around to look at others when saying 'It's the history of war!' in an excited voice."

"There was a gesture from one user in the RecRoom lobby whose discussion I was observing. The user slumped their arms down just like slumping one's shoulders in defeat. With his tone of voice sounding rather lost/desperate/confused the meaning of this gesture was clearly distinguishable."
"A user let out a simple 'Yay!' with hands up. Definitely made the verbal message seem more sincere."

"The orange robot user had multiple 'maybe' or 'I don't know' answers that were supported with a slight lift of both hands, palms facing up."

"Repeating gestures could be seen to be used most commonly coupled with a greetings or with answers regarding virtual objects. A simple waving motion often reassures that the verbal message is received by the intended user, especially in cluttered spaces with a lot of people speaking simultaneously. It is sometimes rather difficult to locate the speaker despite the lip animations of the avatars. Pointing to an object on the other hand is rather commonly used as it seems to be one of the simplest gestures utilizing the possibility for real-time gesturing and shared context."

"On Recroyale a user asked another user that had just joined my party to join them in a squad with a fist pump and he denied the offer by turning his head and raising his hands. It was very polite. The movement was soft and calm and the message was very clear. I believe this might have also reflected the user's internal cues, his personality in a sense. He was respectful and that gesture and its politeness was heavily supported by his other behavior. He did not swarm us when he wanted to join our team but rather asked politely. It is an interesting interaction since in VR the additional possibility to swarm someone is there due to the lack of haptic feedback and seems quite regular in the Recroom context."

"Since movement is tied to hands, gestures coupled with movement are fairly hard if not impossible. This for instance in situations where one would indicate that another person is too close as was witnessed during the observations. In the situation a person raised their hands in front of themselves to shield themselves from the other user that was getting too overwhelming. The loud person pushed through the player's personal place rather intentionally. While the initial hand raising was combined with a slight movement back as the person moved in real life it did not enable the user being intruded to move away from the intruder in an extent that would've seen appropriate."

“Two experienced users were passing marshmallow sticks to one another. It was quite interesting to observe these two users as they used the interface quite smoothly (locomotion a bit too quickly at times). I believe this might’ve affected the fact that the users seemed quite confident in the space. They initialized discussions and had no problem interacting even through the motion control enabled communication methods, such as hand gestures. At one point one of them even made a comment while using the ‘quotation mark’ -gesture. The quotations marks were used very smoothly, which would indicate the user was indeed familiar with the interface. Supported by the tone of voice it was very clear that the hand next to the head clutching its fingers was indeed quotation marks.”

“Turning one’s head and waving to people is an easy way to communicate with individuals without striking up a full-on conversation.”
“Waving for attention is a regular thing to do, gesturing that one has something to say/show. Happens naturally.”

“A person joined us, not talking actively. However, I turned my head towards them to acknowledge them. I believe my discussion partner at that moment did so as well. We did it briefly and due to not getting an active response from the person approaching us, we continued our discussion.”

“I attended an event in AltspaceVR for musicians, where people gathered in a rather small space with a couple of sofa arrangements at the back and a microphone in the front. There was also a table with virtual coffee served. The coffee got a few laughs as people tried to break the ice. As the event got more crowded the creator of the event took the stage. At this point most discussions seized and were replaced with silent nods of agreement towards the speaker. There were some attempts for whispering between smaller groups, but as the space was so small these quickly died out as disruptive. The people also rearranged themselves at points through the use of pointing gestures.”

“The black clothed player vanished to his own home space, to where we followed him through a portal. We went to the ’living room’ space of his home space and watched Imagine Dragons Youtube videos. I told the host I liked the music. He then approached me and we ‘fist pumped’ to recognize mutual respect.”

“I was playing one of the dungeon quest co-op games with another user and as we progressed one of us would be taken out by the game villains in various situations. This traversed us into a grey screen and had us wait until the other player would come to us

and give us a ‘high five’. This gesture was amplified with an audio cue and a haptic feedback into the controller, as well as functioning as the ‘revive’ button in the game. In addition to this we decided together with the other player to add each other as ‘friends’ on the RecRoom platform. This happened through a handshake, accompanied with a similar, yet distinguishable audio and haptic feedback as in the high five revive function.”

“A user entered the campfire in AltspaceVR and was recognized by another user. The two friends then greeted each other by hugging one another. This was interesting to observe as the gesture seemed rather genuine, even though previous experience has many times proved that such direct contact can sometimes feel rather odd without proper feedback for the touch.”

“I wanted to talk to a person when there was another discussion going on. Because I did not want to disrupt the discussion, I did not want to draw his attention by talking. Therefore, I instinctively tried to bump his shoulder. I realized only after that of course such a gesture was not possible. However, I believe waving a hand in front of his face or trying to jump around his field of vision were not options either. Therefore, a non-auditive, private “attention draw” was needed, but not available.”

“A user kept moving back and forth in a rather large area of space as I approached a group. The campfire space was rather empty, so I merely approached these few users there and started chatting about our VR equipment etc. It started to bug me a bit that one of the users, that looked like a vampire with their red eyes and pale face, was constantly moving back and forth. I guess the motion to move around is so tiny with the controller that they were just playing around with it. Yet it made the user seem very restless, as they were moving several meters back and forth in the virtual space.”

“Repeated swaying, seems more like pacing sideways with feet rather than the controller. The orange robot person kept swaying from side to side with their hands hanging in the air in a way that made me think that they might not be holding their controllers. I have seen the similar movement earlier with the so-called vampire guy, but this time I believe it was feet moving rather than controller movement. Both of these communicated a level of uneasiness or restlessness. However, the controller based rapid movements gave an impression that the user was very restless while the swaying was much more subtle.”

“I observed a conversation between an Oculus Go user and a full 6DoF HMD user. I’ve learned to distinguish the two quite well, as Go users have one active hand while the other lays motionless on the side. The hand movements of the other user make their technology rather obvious. The oculus go user seemed to hover back and forth constantly. He also

turned around periodically. It gave a restless air, just like he would be trying to match the amount of activity the Oculus Rift/HTC Vive user is able to give. Or it might almost be like a head nod, active listening."

"We were talking about the show Overlord with a user in AltspaceVR and he was moving his hand rather actively as he was speaking, which is rarer with Oculus Go users. The motion was a half circle from his side to in front, upward (clockwise?) and back. During the discussion he also came too close to me, vanishing from my view as he entered my personal space bubble. He apologized after becoming invisible, which would indicate he recognized the action to be quite intrusive. I did feel the need to move, as I lost vision of my conversational counterpart."

"A player was playing the xylophone and another rudely teleported to his face to play it. He then stated that the newcomer was "awkwardly close." He then moved away."

"People started dancing, pumping their hands up and down, as well as their head. This happened when a person came with a stereo to us. This non-verbal reaction made it clear that the person was recognized, and their activity was approved as people joined in and behaved accordingly."
"On the other hand, before this event a player approached a couple of other players tuning their options. Even thou the approaching player came close the other players did not get bothered and did not react to his presence. Therefore, they did not compliment the expected social cue waited for and therefore non-verbally refused the approach."

"One of the more experienced users kept dashing around the space in a pace that was hard to follow. As they moved through the 50-100 meter space in half a second it was quite hard to follow. At times this rapid movement brought him behind me and the only way I kept track was hearing his voice suddenly behind me. At other points there was a several second delay, as I needed to look around to figure out where he vanished to."

"Regularly moving people give a lot clearer point of direction and thus also have a more natural speed for their proximity changes. Teleportation makes changes quick and frantic, especially when you are facing a person and they suddenly vanish from your field of view. Therefore, steady movement might be preferred in social interaction, since it gives more information on the transformation of one's position."

"While exploring the 'Ori amusement park' environment in AltspaceVR with another user I noticed there are many issues with positioning in relation to another user and keeping track of their movement and location. As we moved around the area and our attention

moved from one another to the world and back there were many situations where the other person was not located in the place they previously were. Even if a person is standing right next to you, there is no way of knowing that if they don't stand in your field of vision. And what is completely flipped is the fact that if the person gets too close, they vanish. Therefore, rather than having more sensory information from them, you lose what you already had. Even spatial audio doesn't help you locate a user if they are too close to you, as it is not accurate enough."
"We ran over the edge of the amusement park with the other user and noticed floating cars, virtual towers and animals around the main island. We also looked at the surrounding artwork that was in the horizon. Due to not having any land beneath us and at times moving very far away from the other game objects, it was hard to measure distance. Therefore, there were many situations where we drifted outside of each other's audio 'proximity', out of range for the other to hear. Therefore, there were multiple situations where we turned our heads looking for the other and asked loudly 'where are you?' followed by a 'there you are' when the other user was located. This was much due to teleporting and little feedback on the other player's movement, as there is not any audio or haptic feedback. The teleportation is also such a quick method of movement that the other person moves outside of audio range in an instant. This lack of feedback is hard to adapt to as it would require a rather unusual discourse on tracking the other players movement and location through verbal communication constantly."

"There was also a group of artistically dressed avatars grouped up (artistic meaning a beret and a tad fancier clothing). These groups are quite frequent and usually give a very unique air to them. They seem to represent their own culture which seems hard to approach if you are not part of those individuals. This is mostly indicated by the high threshold of presence needed to be given to these kinds of groups before getting a response. This time a remark on the topic being discussed at the moment (which was musical instruments) was a way to get their attention and join the discussion briefly. Yet due to lack of eye contact and no change in the circle positioning there was no indication that I would've been taken in as a full member of the discussion."

"Teleport precision is not always right on place. I've had a hard time at points to pinpoint my location precisely when I'm on top of objects or even in a discussion circle. It is hard to therefore position with the teleportation and I've felt rather embarrassed at times when I mistakenly teleported too close to someone or in the middle of the circle, merely because I did not really land to the spot the teleportation indicator showed."

"I was observing two users that I had previously chatted with myself in order to better get an objective view on the cues they used. One of them were using a male avatar and the

other, presumably female based on their voice, was represented as a blue robot. A new user then entered the space, first approached me and then the two users I was observing. The person moved close to the two users discussing with one another and said ‘hey!’ in order to get their attention. The male user first moved closer to the robot user and it seemed like the duo was not ready to attend to this new interruption. This made the approaching user be silent for a bit before trying again with a ‘hey, excuse me’ which got a reaction and initialized a discussion between the three. The new user therefore seemed to be required to hover for a while before being given access to be a part of the group.”

“Within teams interaction in RecRoyale was based on huddling up in the pre-game bus and discussing where to go. The map worked as a shared viewpoint. The situation resembled well the real-life situation of sharing a map and naming places in it. I noticed however that I was missing the pointing feature in the game as it was hard to lean in to see where the other player was looking in their map and precisely point my suggestion there. Therefore, I believe a 2D desktop pinging that gives players indication on where everyone wants to go works more efficiently from the task orientation point of view, as locations are pinged and marked in a single, shared map. However, the pre-game communication in VR might’ve stirred deeper collaboration due to the gathering round effect. People were not communicating from a distance, but because of the spatial audio feature needed to come closer to one another and therefore create their own space separate from the other groups, therefore indicating that we were a team.”

“It would seem that in larger groups people would need to actively wave their hands in order to make sure them talking, or having something to say, would be recognized. Spatial audio does not seem enough for spotting who is talking. However, these kinds of hand gestures seem rather rare. This problem of recognizing who is speaking is quite a common one in VR discussion circles when multiple people are talking at once. The animated activity cues, moving lips and flashing lights on robot avatars become hard to track. Especially difficult is identifying who exactly is speaking, as it is hard to connect audio with visual cues. This is mostly a problem in larger group dynamics, not so much in 101 discussions.”

Field notes:

4.5.2019

Recroom

Making friends through handshakes and reviving through high fives.
It would seem that **natural non-verbal cues can be enhanced by coding certain functionalities in them**.
This observation was further reaffirmed as I did observations inside the AltspaceVR environment. There these gestures lack the haptic and audio feedback and do not offer the same kind of functionality they have in Recroom.

It has been noted that handshakes and high fives do not offer the same kind of audio/haptic feedback in AltspaceVR as they do in RecRoom. This creates a rather visible difference in the amount those interactions are used. Especially the high fives are rather common in RecRoom as people play around with the audio feedback by repeatly hitting each other's virtual hands in order to create the sound.

Contextual discussions: Discussions about the VR context shared with the other users feels quite natural. I wonder if talking about the person's digital profile is easier due to the increase in presence. Presence makes the platform specific digital profile a lot more direct, apparent, immediate than for instance talking about ones facebook profile in facebook. Is there indeed a digital identity that forms much stronger in VR than it would in other digital platforms?
I talked with a user about our avatars and the choices one can make in clothing. Talking about avatar clothing felt casual and fitting to the context. (But what the heck we're we wearing???)

The conversation was initialized by a comment on the observer's avatar's looks, a white male with a short beard, red shirt and a tie. The discussion progressed to the various choices one could make in their appearance inside the game. While generally the design of the user's avatar was talked about as if manipulation an external object, there were also comments like "I look like…" or "my jacket…" which would imply that the user recognised the avatar as their own individual representation of self within the platform.

6.5.2019

The evening started with me approaching a couple of people at the café. One was ringing the bell intensely and the other serving coffee, double jugging it etc. I was first met with a bit of variness, as I believe my comment on the snacks not

being grabbable just like that was reacted to with a level of uncertainty. Uncertainty towards me as a character and who I was, not towards the food being unavailable without purchase.

Direct interaction was scarce before some time had been spent among shared elements in the space. We looked at pictures and made single remarks about things, "poking the ice" in a sense, trying to break it. After a while however sharing the interactive elements in the space became easier and more frequent, and most of all more direct. Messages were directed to individuals and names (usernames) were established.

Befriendement was quick, in the platform since, adding each other. After that is was the random mayhem **interaction** where I picked a few pointers that are described below.

During the discussion he also came too close to me, vanishing from my view as he came too close.
People like to interact closely, it does give a sense of being close to others.
It does also make it hard to initially approach a crowd. Clicks?

High fives with sound effects. Gestures coupled with feedback feel instantly more impactful.

Taking selfies was cool, gave a really authentic feel of sharing a moment with a group of friends. Although I can't say I would feel any high levels of affection towards the folk. Although it did feel pretty cool to suddenly feel welcome in the space.
Creation of rapport in VR? Environment and context are a big thing in communication, having someone feel welcome in a space might be beneficial in a VR space alike it would be when inviting someone to your home/office.

Mute user is still not conveying a lot of information, but even silent people are able to be part of activities and recognised.

Waving for attention is a regular thing to do, gesturing that one has something to say/show happens naturally.

Dancing is definitely recognizable through the up and down hand pumping.
→ **Mimicked movement**. Conveys that the gesture was received and understood, shows active listening and interaction.

Teleportation as a means of moving is definitely confusing when it's hard to keep track of where people are going.

Interaction with stuff gives space for innovation, coming up with new ideas on how to mess around with them. New ideas also give space for creating an interesting persona for oneself. Being creative and innovative, boldly showing ones skills or staying as an observer at the background. However whether or not these choices rely on ones "free choice" representing their persona, or on their ability to use the VR system or to be restricted by it?

People again **sharing** their VR set up, describing **real world** environments.

Personal space through ghost effect. Player becomes transparent when too close.

A lot of mute players, I should examine that. They definitely are recognised as being there. Interaction is possible through activities. Interpersonal communication though? What of the given communication literature areas can be served without voice? How does **the interpersonal feedback loop** work in regards of mute players, in VR?

Also how do I take interactions with virtual stuff into account? That is not exactly interpersonal communication is it? Maybe it is the paradigm in VR

Having your photo taken and shared, How did that feel? I do identify that it is me there, but only my avatar self, so the **identity** is limited to these people and completely in my control. If things go south, that avatar can vanish, I can delete it. Yet being marked into a picture with other people does leave a mark to outsiders to see that there is indeed a relationship between the two avatars. If and when avatars are recognisable, does this imply similar social norms than it would in real life? Commitment to publicly stated relations and friendships?

"Rec royale. People were very helpful in the lobby. Many people talking at the same time was hard, but on the other hand the VR does enable signalling. Initially my attention was drawn with audio, calling for my username, but after that I was able to focus my attention mostly through eye contact. I also signalled not hearing the other person by leaning towards them."

The players that beat me first off apologised, because they recognised me as a new player that didn't know the game yet.

Compared to other similar games like Fortnite the pregame lobby had much more active interaction. People were huddled up in groups and interacting actively. Some people were clearly prior aquintances and were discussing in a circle. The closed circle did not invite to join as it quite clearly indicated a closed click. Others however interacted with the various game elements with each other to pass the time. Some were very helpful and discussed the game.

Flaming seemed lesser, at least from initial experience. There were signs of frustration when people were defeated in the game and had to rejoin the waiting lobby. However, these outbursts seldom were directed towards other players. Within teams interaction was based on huddling up in the pre-game bus and discussing where to go. The map worked as a shared viewpoint. The situation resembled well the real life situation of sharing a map and naming places in it. I noticed however that I was missing the pointing feature in the game as it was hard to lean in to see where the other player was looking in their map and precisely point my suggestion there. Therefore, I believe a 2D desktop pinging that gives players indication on where everyone wants to go works more efficiently from the task orientation point of view. However, the pre-game communication in VR might've stirred deeper collaboration due to the gathering round effect. People were not communicating from a distance, but because of the spatial audio feature needed to come closer to one another and therefore create their own space separate from the other groups, therefore indicating that we were a team.

8.5.2019 klo 16.45

Internal cues.
Agitation is pretty easy to communicate by quick jerks of movement. A person took another one's toy away and the frustration was shown by whailing at the other player.
Also, aggressive treatment of in game objectives would seem to indicate levels of frustration.

Paralanguage, does it get any boosts? Supporting paralanguage with other dimensions?
The Ryan hand raising denial gesture was this, his tone of voice and polite gesturing supported each other.

Facial expressions: automatic therefore misguiding? Miscuing and the trade off between lively character and miscommunication.

Gestures:

Patting head, pointing, high fiving, Dancing moves very clear, walking still is head popping. stuff into people's face, handing things, pushing people away, pointing vs doublepointing, thumbs up.

I believe gestures need to be overemphasised in VR. One user patted me in the head when we were playing as what I believe was a gesture for friendship and affection. This however would be very extreme in a real world environment. Also there probably was a hint of superiority being communicated as I was the noob, which is inherent for the gesture itself.
Another note is that since there was no haptic feedback, I only realised I was petted by seeing it. This means that these kinds of cues are a lot less reliable to give the intended message, since the gesturer might fail to realise the lacks in the receiver end. There is a high chance for the petted not being able to notice the gesture and therefore it creates asymmetry in the information between those two people, the petter not realising that their gesture was not received.

On Recroyale a person asked a young, blond avatar user to join them in a squad with a fist pump and he denied by nodding and rising his hands. It was very polite. The movement was soft and calm, and the gesture was very nice.
I believe this also reflected on the user's internal cues, his personality in a sense. He was respectful and that gesture and its politeness was heavily supported by his other behaviour. He did not swarm us when he wanted to join our team but rather asked politely. It is an interesting interaction since in VR the additional possibility to swarm someone is there and seems quite regular in the Recroom context (young players).

Locomotion: Does teleportation give space for this?
Regularly moving people give a lot clearer point of direction and thus also have a more natural speed for their proximity changes. Teleportation makes changes quick and frantic, especially when you are facing a person and they suddenly vanish from your field of view. Therefore, steady movement might be preferred in a social interaction sense, since it gives more information on the transformation of one's position.

Locomotion and gesturing. Since movement is tied to hands gestured coupled with movement and fairly hard if not impossible. This for instance in situations where one would indicate that another person is too close as was witnessed during the observations. In the situation a person raised their hands in front of themselves to shield themselves from the other user that was getting too overwhelming. The loud person pushed through the player's personal place rather

intentionally. While the initial hand raising was combined with a slight movement back as the person moved in real life it did not enable the user being intruded to move away from the intruder in an extent that would've seen appropriate.

, the actual movement looked more like the person intruded would be running away than backing away.

Pacing: Can it be noticed?

The Polish drawing guy was quite a poor interaction. With no vocal indicators and slow pace in the communication I felt like I wasn't giving much. Still I felt like the lad liked me. Why? He did turn towards me after writing stuff, indicating that it was important for him to be heard and to hear my comment. I believe the pace of writing might have varied also, but whether the beginning was slower than other parts, I can't really say. I would however state that there was indeed a recognisable change in his pacing, the energy and speed of his movements that gave me indication that the polish person was being activated and stimulated positively.

Contextual cues and avatar appearances.

Habit analysis, longer period analysis on a single individual.

(People adapting to the VR environment and adjusting their behavioural cueing.)

Misunderstandings and misinterpretations.

There was an actual peace offering in rec royale , that was a new one. Could not imagine that happening in regular battle royale.

The mic voice and the proximity voices are really different.

During the Jumbo play the one angry guy that insisted we play good wanted people to shut up, and shut himself up when I shot him and told him to do so. He was being very angry and impolite to me and the younger players all through the play session. However, it seemed that me talking back had an effect, the negative comments became less frequent. I wonder if this was caused by the gesture of shooting him and having the system give him the death notification. This would be interesting in the context of having a "flagging" function that works as an emphasis on urgency, other than raising your voice. What kind

of things like these could be structured into the VR systems in order to create communicationally supportive functions? Expansions on impolite but sometimes necessary cues that could be created better than their real-life counter parts.
Conflict management in VR also does seem easier, there is definitely more outbursts, but also an active attempt to confront those outbursts. (the petting user with the mean guy).

There was a **gesture** from the one guy at the lobby whose discussion I observed where he slumped his arms down just like slumping ones shoulders in defeat. With his tone of voice sounding rather lost/desperate/confused this gesture was recognisable. There might be a chance that these kinds of gestures, while failing to mimick the real'life counterpart, might still be able to convey the right message when coupled with other information.

9.5.2019

Complementing: Emphasising messages. Gestures and movements that support the verbal audio message.

Contradicting: Opposite, non-supportive. Confusing and mixing gestures.

Repeating. Doing the same thing with verbal and non-verbal. Pointing for example.

Regulating: Controlling and restricting others. Raising a hand to gesture someone to wait their turn, gestures indicating speech. Overlaps with complementing easily?

Substitutes. Non-verbal instead of verbal. Pointing again.

Accenting: Crazy hand flailing etc.

Presence in a room definitely does not imply social presence automatically. (As Benford emphasises in his work the activity feature**). Activity** and "activation" of social interaction seems to be important in open VR spaces where people come and go freely.

In private spaces this does seem different however, as joining a room with a previously established group of friends does get an instant reaction. As I jumped in and out of rooms looking for suitable environment for social interaction I encountered a room with a group of people already in a discussion. As the group was in discussion already and the room had no other purpose than for people to come and socialize, it seemed that my entrance implied a lot more social presence than in previous experiences. This was different from the RecCenter, which is the main area of RecRoom and where people come and go quite frequently so individuals are not automatically recognised. Therefore it seemed my social presence was automatically implied with my presence in the social room, but not within the RecCenter.

Deactivation definitely needs to be signalled. There'd been multiple situations where inactive players have seemed like they would be present, but they were not.

Talk with a user from Texas. The communication is quite weak… Not a lot of cueing. He did move his hands every once in a while. Sometimes it was hard to figure out if he was gesturing something that was intended for me. Once he raised his hand to his chin like he would be pondering or scratching it. However, I felt **I couldn't trust that cue** as being intended in that way as it might've been just him doing something in real life. Movement towards and around the player's own face is quite common here as people adjust their headsets. Therefore, raising ones hands on the side of their head loses meaning, as it needs to be very overly done in order not to be mistaken as headset adjustment.

The user did move his hands about at times. I believe that is complementing the discussion as it does give some indication on the calmness of the person. The engagement during the discussion did remain quite low, which was emphasised by the low movement of hands. However more than that the orientation of the user's head probably gave most indication of some level of insecurity and discomfort. He was looking down for most of the discussion. I do believe this affected my own approach a bit as I tried to make him feel more comfortable by showing a lot of agreement and avoiding any kind of conflicting views on things. There might have also been some swaying from side to side, but I'm not sure.

The discussion with the user from Texas was quite open and we discussed personal information quite quickly. The user especially didn't feel like he would've felt the need to hide things. This higher level of trust might be misleading

though as I don't believe the openness had quite the same effect in VR as it would've had in real life. Showing trust through an avatar in a virtual context might have made me feel more disconnected with the person in front of me rather than closer. It felt like he was talking about the real-world situation, which was in accessible in the VR environment where we were having the discussion in. This disconnection with the spoken environment might've given a feeling of disconnection with the person in front of me, possibly through the break in coherence and immersion or possibly for other reasons.

11.05.2019

You + pointing, who bought you that hat? tapping the hat.

Wave, substituting.

nodding, substituting.

Raising an object to make people look at it.

Accenting a sound effect with a hand gesture. Movement sound like voosh with a hand movement to a direction.

Look at that, when pointing to a moving object, complementing.

Offering an object/throwing it towards you.

22.05.2019

I had to use the regular controller while I charged my batteries and I noticed there is a set of pre-programmed non-verbal messages in RecRoom. These include the Social functions: waving, partying up (wave + fist pump), friending (wave + handshake) and High five. Negative messages are Angry (Fists down in front), sad (fists rubbing eyes), Embarrassed (covering face with hands) and shaking one's head. Positive messages are nodding, celebrating (fist pumping up), laughing (hands in a triangle in front of face) and love (blow kiss). In addition to this I noticed that the controller players that can be recognised from their even walking and very strict hand movements, have idle animations. These idle animations make them harder to distinguish from VR players and give them an air of activity. (Idle animations include swiping sweat from ones forehead,

slight head movements, touching the back of ones head and tapping shoulders and the air in front with hands, swaying from one side to another and changing facial expressions.
You can also do a Wow! and In Your Face animation (mind blown movement and pointing at another player.

It would seem there is a slightly higher threshold to use non-verbal cues when they are tied to controller clicks than when they can be done through a natural interface by moving ones hands. Audio messages are not complimented with non-verbal as much as the preprogramed are used in giving clear, direct mute messages.
This can be seen from the lesser amount of hand waving and other non-verbal interaction and having people rely more on audio. It would also seem there is a lot less huddling up and socializing. People are more scattered and not jumping at each others faces doing random things like they usually are (random things like waving hands, messing around with water bottles and frisbees etc.)

There is also an increased amount of people standing around. This might imply that immersion increases activity and makes it a higher threshold to leave the game for idle time.

Switching to VR the change in idle animations is very different. People aren't controlled by pre-programmed animations, but their idle activity level is instead determined by their own real-life hand movements and head movements. This would seem to create a lot more unnatural movement as the hands hover into awkward angles. Some move their hands too much in front of them and some turn the controllers so that the wrists twist too much. Therefore, the hand movements are motion controlled and therefore might be seen as based more on natural movement, but because of the tracking of the head and the hands and not the whole body, some movements would seem quite unnerving rather than natural.

There was one person that approached a person quite aggressively, pointing at them to strengthen their messages on "who are you and what are you doing here." The eye contact, close proximity and pointing definitely was a complementing/accenting feature.

Some person also waved their hands quite extensively. This was???

pointing again a substituting message.

Hands on head is usually a fix on the headset rather than virtual world communication.

Waving one's hands to dance. Up and down, either fists, or flat hands, or pointing up in the air. also head pouncing. This when a person came with a stereo to us. This non-verbal reaction made it clear that the person was recognised and their activity was approved as people joined and behaved accordingly.

On the other hand, before this event a player approached a couple of other players tuning their options. Even thou the approaching player came close the other players did not get bothered and did not react to his presence. Therefore, they did not compliment the expected social cue waited for and therefore non-verbally refused the approach.

I got instantly approached by a player pouring water on me in the game. It would also seem the amount of idle players is lesser. Although given the chance no verbal messing around is only tied to objects.

Holding out objects to direct attention to them is rather common. Also pointing. Happened when talking about different colour weapons inside recroyale.

The "flaming" behaviour is present. Or at least a lesser amount of filtering. Young sounding players curse a lot and use inapproapriate language. Words like "motherfucker" or references to genitals is quite common, sometimes in a way that they are repeated constantly. Also there is a lot more aggressive discussions with quite insulting remarks. Approaches like "what are you doing here?" are quite common and people show annoyance. Some people also act annoyingly. Example for this is a person that whistled Christmas tunes quite loudly, which gave an instant negative reaction from some players. The initial annoyed "who is doing that" was followed by a kick vote for the player.

There was also a group of artistically dressed avatars grouped up (artistic meaning a barret and a tad fancier clothing). These groups are quite frequent and usually give a very unique air to them. They seem to represent their own culture which seems hard to approach if you are not part of those individuals. This is mostly indicated by the high threshold of presence needed to be given to these kinds of groups before getting a response. This time a remark on the topic being discussed at the moment (which was musical instruments) was a way to get their attention and join the discussion briefly. Yet due to lack of eye contact and no change in the circle positioning there was no indication that I would've been taken in as a full member of the discussion.

23.5.2019

AltspaceVR

The person I was talking to had an oculus go controller so I couldn't get much out of his non-verbal communication. However, there were a few situations that made me aware of my own activities.
A person joined us, not talking actively. However, I turned my head towards them to acknowledge them. I believe my discussion partner at that moment did so as well. We did it briefly and due to not getting an active response from the person approaching us, we continued our discussion. (This is an example of complementing communication, as it emphasises/supports a possible "hi there" or even substitutes that. Without the shift in eye contact the person might not understand they are recognised, if you compare it to a situation where the head turning would be missing and the recognition would be merely an audio one.) This would imply that VR also makes it a requirement to actively use non-verbal communication as it is possible. Therefore leaving a cue out might lead to a misunderstanding.

In another moment I turned my head and looked at the scenery. I believe that was a moment between the shift from one topic to another or at least a conclusion of a point made. This would imply the motion control gives a natural method for pacing one on one communication as empty moments can be filled with activity. Signals on a topic being "processed" and thought about etc.

I believe I actively thrived to use non-verbal cues at points as the other person could not do so. There is a possibility that my ability to communicate more richly gave me a stronger position in the discussion and therefore made it more socially acceptable to take lead in the discussion. This might be a **recurring phenomena**, we'll have to see.
Some of these cues were for example showing measure. Distance is quite natural to show by stretching one's hands. Another is comparison between the level of something, indicating that there is a difference in scale. This kind of way to communicate relativity is quite handy. Pushing something down and lifting another up, showing spots on an imaginary map etc. Another non-verbal cue was me creating my VR grid in the air, drawing the play area with my hands. One was showing the action of breaking a window while playing VR by a sharp shove with a hand to the side.

The female user, that might've been an employee, confirmed the immersion point. She said that after a time of using Altspace she realised that she's not chatting with friends in different locations, but it was more like sharing the same space with the person. That to her was the main point. She had used VR for 3 years and for what I understood might be working for AltspaceVR.
She also told that to her experience VR has been a great tool for many to win their social anxiety and to turn around their X(Msomething) from introverted to extroverted.

"A user entered the campfire in AltspaceVR and was recognized by another user. The two friends then greeted each other by hugging one another. This was interesting to observe as the gesture seemed rather genuine, even though previous experience has many times proved that such direct contact can sometimes feel rather odd without proper feedback for the touch."

Lifting one's hand to a "what are you going to do". indicating "I don't know". The employee asked the orange robot person about something and the answer was "I don't know" supported by a very clear spreading of his hands up on his sides.…

Audio over each other. The employee and the orange robot talked over one another at points. It would seem that although the chance for regulating gestures is there, they are seldom used. Active utilization of non-verbal cues in these kinds of situations seem scarce. There might be a chance for hand gestures, but they are utilized a lot less generally than for example how I use them. In addition, it would seem that presence and immersion does not quite solve the speaking over one another issue. The audio still comes in from a pipe when people are gathered round and are not talking from opposite sides or from distinguished distances. Therefore, the spatial audio does not regulate the turns to speak enough as it is.

Maybe and insecurity, uncertainty is easy to cue. The orange robot had multiple "maybe" or "I don't know" answers that were supported with a slight lift of both hands, palms facing up. This was a clear accenting cues.

24.5.2019

RecRoom

Playing with **regular controllers** again. I don't have my microphone on, which greatly lifts the threshold to interact with people through small casual things like waves and such. I do however believe that more than the lack of audio the small interactions are lesser due to the fact that I have no ability to spontaneously gesture. A couple of players approached me and as waving required intentional button pressing in order to give a wave the message was given later. Because of the delay in my reaction I believe the people approaching me thought I was not up for any interaction and therefore moved on.

I dare say that the lack of audio is not a solely determinant factor in the chance of threshold for interaction in this situation as I have many times observed silently within VR with audio too. There however turning one's head and waving to people is an easy way to communicate with individuals without striking up a full on conversation. The motion-controlled gestures are also more accurate in a way that they give the possibility to gesture to a person in a distance without the level of vagueness that I encountered with controller based pre animation waving.

An interesting moment in the controller environment was that I encountered a player I had spent time before that approached me very friendlily. He/she then started petting me, which instantly made me move away from the character. This was a very interesting moment as the movement was completely spontaneous, enabled by the fact that I have used the controller movement so much while playing games that the movement was able to be a **reflex**. This has not been the case in many of the situations where players have petted me in previous situations, as this kind of "physical" contact is quite common in the RecRoom environment. I have wondered how exactly does the dynamic of this kind of intimate distance breaking interaction work in immersive virtual reality. Yet through this comparison with the controller environment that is not immersive but was done through a 2D screen with little immersion it would seem that there might be some contradiction. One would believe that the motion control and full immersion would give a stronger impulsive/reflex based reaction to a gesture like petting ones face. Yet it would seem that this reflex was stronger in controller based environment instead. I at this moment believe that it is due to the controller movement being move familiar and therefore having the possibility for more spontaneity, VR movements being less familiar and harder to use especially in this kind of situation where the reflex movement was indeed backwards, backing away from the petting gesture, because in VR backwards movement is quite unnatural when using teleportation (which is my preferred movement style.)

Spreading ones hands on the sides in a dramatic manner when saying “the museum of time” in a voice with wonder, nice effect.

Turning around to look at others when saying “it’s the history of war!” in an excited voice. Guy at the museum of time.

“Yes and I would be put here” with a hands spreading to indicate the space to give meaning to the reference “here”

Dropping into the water, swinging ones hands like he was drowning.

Total loss of controller tracking made my hands move to my side instead of in front of me. Technological error completely disrupted my ability to communicate clearly with a person that was trying to interact with me without audio by coming close and trying to party up = fist pump. **Had to restart the game**.

Also the bug in the WW2 museum that made me lose my group of people at that time. Had to leave it for luck and the message interface to find them again. Technical issues can heavily disrupt interaction when the issue is in tracking. Also encountered a lot of bugs with the video and audio resetting. I believe that distracted me quite a bit and I was unable to join into some of the discussions about the surroundings.

25.5.2019

AltspaceVR

“This guy here”. repeating, going near and pointing. The scott user using a blue robot as an avatar referred to a person when someone asked “who is talking?”. She then moved next to the person and pointed at him, saying “this guy here.” It was very apparent after that.
This problem of recognising who is speaking is quite a common one in VR discussion circles when multiple people are talking at once. The animated activity cues, moving lips and flashing lights on robot avatars become hard to track. Especially difficult is identifying who exactly is speaking, as it is hard to connect audio with visual cues. This is mostly a problem in larger group dynamics, not so much in 101 discussions.

The **rude** guy, “you wanna make out.”, “Are you feeling me up.”, “I’m fisting him.” wanking other people and all. He did mention he had been drinking,

which is probably a factor to the unapproapriate behaviour. But as noted later, there is a rather lot of this activity of physical contact, although usually lacking the rude talk.

Flying robot head emojis instead of hands. People described to a floating head propel robot avatar user after he reacted with a "thanks" and clapping emojis coupled with love emojis. There was a tiny delay to this and the use of emojis would especially seem unviable in the simultaneous manner that the scott lady used her hands in her speak, emphasising messages in real time and "speaking with her hands."

Thumbwars. After realising that one can lower the thumb of the avatar there was a short thumb war coupled with some kind of a "meeny miney mo" kind of thing. A short, but quite well working dynamic.

overload conversation: We were talking about the show Overlord with the rude guy and he was moving his hand rather actively as he was speaking, which is rarer with Oculus Go users. The motion was a half circle from his side to in front, upward (clockwise?) and back. During the discussion he also came too close to me, vanishing from my view as he came too close. He apologized after becoming invisible, which would indicate he recognised the action to be quite intrusive. I did feel the need to move, as I lost vision of my conversational counterpart.

Spatial audio not enough for spotting who is talking, colours and lips don't identify speaker 100%. As mentioned earlier it would seem that in larger groups people would need to actively wave their hands in order to make sure them talking, or having something to say, would be recognized. However, these kinds of hand gestures seem rather rare, especially as most of the users are Oculus Go users.

The Scott, same as "this guy" person. "he was just pushing buttons" while pushing button motion. Contextual motion. also pointing really natural.
In this situation the Scott user was telling a story of something/someone and mentioned button pushing. She pushed the air with her hand in the pointing position, which made the message very clear. This repeating/emphasising gesture could be timed with the speech due to the motion controllers. The user's ability to make her hand into the pointing position without any delay, in real-time with the speech was impressive though. Because of the interface being rather novel I feel that I myself rather often need to think what I want to do with my hands when gesturing, making the gestures more conscious.

Gesturing in real-time would require a more **familiar interface**, as moving your hands the wrong way might conclude to a miscommunication. I have not seen these, at least haven't noted them. yet I have noticed user reluctance to move their hands actively, which might be due to some uncertainty with the interface. This uncertainty might stem from the possibility to miscommunicate if your clench the wrong finger instead of pointing for example.

Scott user: laughing and tilting her head back with her hand on chest. Very neat emphasiser. This tilt of the head seemed to repeat a few times, which might have made me connect the gesture with the person on some level. This might be due to observation, but might also happen unconsciously, connecting a repeated gesture with a personality, thus enhancing identity features of the avatar, connecting to the user.

People tend to move around, might be lack of stimuli? I think the Scott mimicked. The counterpart in the conversation with the Scott user I observed kept moving around constantly, not using a natural interface as he was on Oculus Go, but rather using the controller. This movement is quite apparent. Yet it would seem rather common in the environment. I wonder why that is? Is it because of the imbalance between the Mobile VR users and Wired headset users, their ability motion control in real time?
Also it was interesting to see that I believe the Scottish user mimicked this behaviour at one point.

Height difference, Scott 5,4 and the counterpart was 6,2 and Scott is higher in VR.

They are not minding me, presence not active. I observed the Scott and the counterpart from a bit of a distance.

Personality movement, Scott head tilt laugh.

Interrupt, came close, said hey, the counterpart went closer to bluebell, the Scott. A new user entered the space, first approached me and then the two users I was observing (Scott and the counterpart). The person moved close to them and said "hey!" in order to get their attention. The counterpart first moved closer to the Scott, and it seemed like the duo was not ready to attend to this new interruption. This made the approaching user be silent for a bit before trying again with a "hey, excuse me" which got a reaction and initialised a discussion between the three.
Hovering and repeat gave the space.

Hover moving when looking at my legs made me dizzy. I tried to see what height I was and if movement affected it.

Huge bottle, mind blown. Couple of gestures the Scott user made.

Scott moves her hands quite a lot. Canoe example was good. The Scottish accent makes it a tiny bit harder to understands it and there the hand gesture drawing the canoe in the air helped a lot.
She also referenced to the amount of apples in the garden being huge amounts by spreading her hands.

People have a tendency to get touchy, people have a tendency to come really close and try to touch people's hands or face. It is definitely a weird interaction. Scott got approached like this and she reacted to it. The lack of feedback however killed the interest compared to RecRoom sound effected, which usually encourages that behaviour.

A very basic gesture is tapping the air with your hand when speaking. I'm not quite sure what that does, but it would seem to either support the tempo of the speaking or to emphasise certain words/syllables. The hand gestures do certainly work contextually as the same gesture usually gets meaning from the content of the talk, being rather neutral in meaning independently. This is also true with the tapping movement, the "speaking with ones hands", Italian style.

The counterpart user in the discussion with the Scottish user, oculus go user seems to hover back and forth constantly. He also turns around periodically. It gives a restless air, just like he would be trying to match the amount of activity the Scott is able to give. Or it might almost be like a head nod, active listening.

The Scottish accent does make it harder to understand, active gesturing would help with that. I felt like constantly asking "what" as I did not quite get what she was saying when I actively listened to the conversation rather than listening on the side.

Lots of oculus go users.

Moving away as a user passes you.

pointing at me checking the name.

joking about real life sharing, I'm on bed, take me to dinner. this initialised the name check. The other user was passive with motion at first.

27.5.2019

AltspaceVR

Identity, when changing space. I noticed one of the users that had been with me in the previous place (house party) was now in the next one (spring mountain lodge). This made it easy for me to approach them.

Inactivity, head up and swirl. Talking with a real-world person and then leaving the VR, leaving the gear on the table and thus leaving the avatar to hover there in an unnatural posture for quite a long time. This was the young user that had come to the spring place from the house-warming party.

Come here and petting the slime guy. There was a user with a ghost avatar in the space. He/she kept running through people with marshmallow sticks. After a bit I told the user to "come here" gesturing that with my hands (both hands going from far to closer to me motion). The ghost user then joined us and we petted him to show our appreciation for the marshmallows.

People adding people pointing. This was a particularly interesting interaction as people looked above each other and pointed. This is one of those situations that forms a VR specific norm on its own on how to act when people are adding each other as contacts. I stood there waiting for the discussion to resume. The gesture is quite recognisable, a user looks above another user's head after pointing them and then aims to invisible buttons with their hands.

Trashtalking, insults, got banned. There was a user that joined us with a guest user due to having their own account banned for rude language. Working around the identity issue, changing avatar and name, but still the same person, same voice.

The voice is the only actual, real feature that the person has. The only real part about the avatar. This is only the one unique thing for individuals for identifying themselves, as the avatars is quite similar. One can't be 100% sure about a person being that exact person they talked earlier or no, besides from the voice, some avatar features and the name of the user. However, in real time discussions this might not be enough, as there was a couple of exactly identically looking robots in the space.

Also there was the ghost person. He got special attention for just being a ghost, after their own initial actions of running people through with marshmallow sticks. After noticed he became our mascot and got petted because he was using a unique avatar in that situation, one that no other user had at that time in that space. This is very interesting for the identification feature and personalization, a limited group might successfully distinguish each other by choosing radically different avatars, but if that difference is then matched by someone else joining the group, that unique avatar choice becomes obsolete.

There is also the point of user demographics. It would seem that the avatars themselves don't really give away anything. The distinguishing feature is the voice. The demographic features one can identify quite easily are age, gender and possibly nationality if one is shared. English is the common language used, which seems to be a standard, almost strong enough that people who are not strong in it might stay silent. (This might be the case for some, if not most of the many user's that join the spaces with their mics off.)

There is also a certain norm for same age groups grouping together. As the circles are formed and discussions start up, people usually gather round certain kind of people, which then affects thye context and communication quite a bit. For example, today it was the group of young guys from all over the world joking and messing around (mostly with topics like wanking and sex).

The lack of individuality of avatars (hard to distinguish people or characteristics from avatars) might make the process of identifying the people you actually want to discuss with a lot longer. You have to talk to people to huddle up in your group, which is a definite threshold, but does happen. (Norms of the VR socializing?)

However, the discussions are rather easy to start due to the shared, quite unique experience. The shared technology and the mechanics of the VR environment offer a neutral ground that is mutually shared to start from, which then gives possibility to move onto more personal topics. An example of this was the guy from Philippines that we discussed about the xylophone and played tunes before striking up a conversation about our home countries and time zones.

There is certainly a threshold for learning VR as a method of communication. As the user interface gives way for many false cues (mistaken pointing when using UI, real life movement, mistakes with hand control buttons (grab, point,

thumbs up)). This coupled with the lackings in non-verbal communication features like posture and facial expressions makes things difficult. (

"Haha" and regular talking give out the same exact facial expression, slight movement of mouth or robot flashing. In addition inactive players (that can look hanged) blink. Very uncanny valley. Inactivity and real life interaction in general, good example the situation with the one young user that lifted their head, talked with someone further away in real life and then took off the headset, staying as a hoverin "corpse" for quite a while.

Hovering as movement does not give any indication on how people are moving. One can't naturally communicate people to follow with their pace of steps for example. In addition turning around is quite tricky, if not done by real life movement.

Sender message receiver loop, the interpersonal communication loop is not as robust as in real life as the technical issues bring up the level of noise. Technical issues and lackings in the people's skills to use the VR interface as well as simple technical issues as delay due to connections over-seas increases noise. Messages are harder to send and received in intended way. This happened for example with the user from Philippines as we talked about things, as I believe we talked on top of one another due to the delay. It is quite harmful for the momentum of the discussion.

Continued AltspaceVR

Mode: VR is its own mode for communication? Immersive chatting. Immersion makes you "resistant" for outside distractions. The presence demands fuller attention towards the person you are talking to?

Tenor: Who are you talking to? Picking who to strike up conversations with is more random than in real life, because the cues you can get are more scarce (avatar limitations, lack of information on age, posture, emotional state through facial expressions etc.)

Go limited hand rotation area for motions gestures. whip and ne n e, dance with singing.

looking up, following ones gaze.

summoning portals for people to follow you to another space.

standing on top of fire.

glitches, jumping veeeery high.

28.05.2019

AltspaceVR

Talked to a person from Taiwan using just a mobile phone to talk to me. As the audio was kind of nice and the person had a similar avatar to mine, with eye and mouth animations and even head tracking as he tilted his phone, it felt quite similar to me as if I would be talking to regular VR users (minus the hand gestures, but those are scarce even for Oculus Go users.)
It would seem that even though another user is not using an immersive device, when their representation is similar enough to other VR users the presence is quite same. It is obvious the experience does not have the level of immersion that a VR device could offer if a person is merely using a mobile device. Also due to this fact and the different view, the small screen, I was aware that the user might not have gotten my hand gestures and other cues quite as efficiently. This created a slight feeling of uncertainty as I was not sure if my messages were enforced by my gestures of not. However I did get the feeling that he was getting some of them and wasn't therefore completely oblivious to my hand movements.

Background noise was quite heavy with a group of people talking close by to us. Even though they were about 5-7 meters away, the noise was still rather loud and made it hard for me to hear the Taiwanese user. This might be due to the volume of the user's microphone as especially one user, using an orange robot avatar, seemed to be extra loud. Their discussion was not otherwise agitating, rude or of similar topic, so any special content issues cannot be seen to have caused the disturbance.
To this one might note that there is a possibility for users to alter their audio features and other technical features through the interface of the application, which gives people a possibility to create a more dominant presence to others. Height and volume are two easily recognisable authority features that users can artificially create to one another.

As an interesting side note, I just farted, which is not hearable through the microphone and cannot be detected through smell. This filters some negatively taken features that a user might have and does not let others be bothered by that.

Another user joined the space with the rather disturbing, and unfortunately reoccurring, echo effect. The echo effect is when a person's input audio comes out of their output device. This meaning their audio is played from a stereo rather than headphones and therefore creates noise through the microphone. I can hear myself with a delay through their microphone, which is very unfortunate. The most unfortunate part is that the quickest fix is to mute them, which I do quite quickly after informing them about the problem, because otherwise the noise would disturb too much.

Non-verbal attention, can't bump into a guy to get attention. I wanted to talk to a person when there was another discussion going on. Because I did not want to disrupt the discussion, I did not want to draw his attention by talking. Therefore, I instinctively tried to bump his shoulder. I realised only after that of course such a gesture was not possible. However, I believe waving a hand in front of his face or trying to jump around his field of vision were not options either. Therefore, a non-auditive, private "attention draw" was needed, but not available.

I think people move onto the sides in order not to be swarmed too much. The employee user and the orange robot seem to like talking on the side and I wanted to go over the game limit/fence because the other side was getting crowded. However, I believe people choose these kinds of locations (knowingly or unconsciously?) in order to avoid people from crowding them from both sides and disrupting the whole discussion.

Echo on multiple devices. **Passive users get muted** so they don't distract discussion.

Looking down, internal attention? people not active in discussion? There were a couple of players around that looked at their hands or something else, me included. I noticed this as I tried the hand controls to the side where no one was in. I then turned my head and noticed a couple of other users doing the same thing. I believe this might be rather common for more passive discussion participants or side viewers. The distracted mind, and shift in attention, is quite noticeable. Yet due to the asynchronous information in VR one cannot know

whether that attention is drawn by real life or invisible game interfaces, or perhaps the shared environment.

Holograms against humanity was kind of interesting. It's cards against humanity, the card game, but with virtual cards and interface. The people are dealt a scenario and they pick random things to fill blanks. There is quite little interaction between people other than voice, which creates the classic audio problem as in video conferences: only few can talk or otherwise it's mush. Because of the headphones outputting the sound the 3D audio needs to be very high quality in order for people to pinpoint who is talking at what moment, even if they don't know their voice, just based on the location/origin of the sound. "Who is talking" is a valid question.
Especially when even the virtual game table is enough to obstruct view and keep people far away enough for not being able to see facial animations clearly. Hand gesturing is quite difficult to track due to the distance and obstruction too, as hand gesture "accuracy" weakens quite a bit from distance. However I do believe I spotted the person who was trying to kick vote people, as it seemed they were aiming above other players' heads in order to click the kick button. I'm not a 100%, but 70%.

29.05.2019

AltspaceVR

klo 20:00. I'm usually here at 16:00-18:00

There was a discussion about some VR device rendering issue or something similar, where multiple users put their hands in front of them parallel to depict two planes/surfaces, as they discussed some technical issue on how the system created those surfaces and the issues in it. Relative position of the planes showed through hand gestures, as they showed misalignment and which surface was on top of the other one etc.

Height on perspective. There are clear height differences in the Spring campfire -terrain, and I went up to the rocks when others were discussing on the ground. There was a definite change in perspective. I might have felt a bit more invisible, on the side and observing things. Also, the perspective on gestures etc. was slightly different, although that might have been just distance.

The reason why I went up there was because a user was moving in a circle on the edge of the socializing group circle. I felt it was hard to include in the discussion, it was disturbing to have a person walk through me as well as disrespectful. I felt like I was being undermined and that if I would've let the person walk "over" me all the time I would be humiliated.

Voice alteration. There is a possibility to change one's voice in Altspace. Rather radically, to robot voices and such, at least apparently. This came up as there was a young user that was interrogated about his age, which apparently was 12 years. As Altspace age limit is 13 years, the other users pointed that out and told the young user to come back next year. After the incident another user (the one that did not initialize the interrogation, but scooped over) started showing the different voice alterations.
Another user scooped closer to make a point in this situation I believe.

Wonder how graphic fidelity would affect communicating. There is not so much uncanny valley in normal discussions in Altspace, but on the other hand as users are so similar, distinguishing one user from another is quite hard.

"" marks. through hands. The quotations marks were used very smoothly, as were other hand gestures by this user and his friend (don't have a name). Supported by the tone of voice it was very clear that the hand next to the head clutching fingers was indeed quotation marks.

Yay with hands up. Definitely made the verbal message seem more sincere.

Passing on marshmallow sticks. The two experienced users were passing marshmallow sticks to one another. It was quite interesting to observe these two users as they used the interface quite smoothly (locomotion a bit too quickly at times). I believe this might've affected the fact that the users seemed quite confident in the space. They initialized discussions and had no problem interacting even through the motion control enabled communication methods, such as hand gestures.

teleportation definitely is too quick to follow. no trace. One of the more experienced users kept dashing around the space in a pace that was hard to follow. As they moved through the 50-100 meter space in half a second it was quite hard to follow. At times this rapid movement brought him behind me and the only way I kept track was hearing his voice suddenly behind me. At other points there was a several second delay, as I needed to look around to figure out where he vanished to.

fixing headset. A common movement with hands is bring them on the side on ones head. Some times this gesture even produces a sound as the user's controllers scratch the headset. This is quite clearly the player adjusting the headset. This adjustment seldom has any visible effect on the avatar, other than the hand movement.

Waving hands rapidly with "nononononoo" to protect marshmellow. Regulating gesture.

passing each other and waving.

hands around user kissing.

grabbing stuff from hand, hurtful.

Go controls: Apparently the tracking of the controller is different. That explains why the Oculus Go users move their hands in such weird movements. Perfect circles and weird heights etc.
Also the young user that I talked about the Go mechanics with showed me some thumbs up and down movements with the Go controller. The thumbs up was ok, maybe went to the side and no went far and to the knee level. Apparently the user was merely turning the controller on the same height.
He also mentioned that this kind of gesture might only be useful if you didn't have your mic on. Therefore it is recognised as a norm that people are allowed to come in the space and interact through mere gestures.

Also we noticed that the 6 DoF of Vive is slightly different from the 3DoF in Go. 3DoF therefore hides some movements, more tracked players give out more information, intentional or not.
There is also the fact that Go users cannot crouch down or change their perspective through a motion like that.

Boo, did not work. jump scare. initialized a discussion. trees. Tried to sneak up on a user that I was talking to an that jumped on top of the trees. Did not seem to work, but sneaking was easy.

Player vanished, no explanation, mid sentence. weird. Probably disconnected. Having given no reason one is left hanging. Also as a player can vanish in a similar way through teleportation (especially from a tree) I thought I just lost him and looked around before realising.

Jaw hand ponder. A user was trying to figure out where a background noise of another player was coming from and put his hand on his jaw.

Awkwardly close. A player was playing the xylophone and another rudely teleported to his face to play it. He then stated this, the fact that the newcomer was "awkwardly close." He then moved away.

Ninja sticks. A user on Oculus Rift was moving quite smoothly. He used the marshmellow sticks as swords and took a ninja pose. There might've even been a slight crouch, indigated by the avatar lowering. One hand in front, other above head, ninja pose.

Drumming, mic drop, The same Oculus Rift user, black clothed avatar player drummed the xylophone and did a few dramatic moves. One was throwing the sticks away after a song ("mic drop"), the other was bringing the sticks high and keeping them there before playing.

Dancing.

Dancing and ninja, smooth tracking.

Come here motion. The Oculus Rift user gestured another player to join us. I followed the direction and was able to welcome the newcomer.

All around hoop motion Shooting hoops, one ball circled the whole hoop before going in, gesturing that along with the amazement.

Home space portal invitation, music. We got invited to the newcomer's home space. Joined in through portal.

User specific volume on music.

Go to, following to home, watching TV. The Rift user vanished to his own home space, to where we then followed him just like that. A "go to" function felt quite intrusive when used like this. Infiltrating another players home.

Fist pump, Music respect. I liked Imagine Dragons and The Rift user then came to me and we instantly fist pumped to recognise the mutual respect for the music.

31.5.2019
AltspaceVR

Interface invisible.

Building rapport through VR. Sharing basic info to know who you are talking with. Talking about the technology is always easy and sharing basic demographics information seems secure as people discourse from behind avatars.

Interaction inequality. Locutionary, illocutionary and perlocutionary points and how they are affected by the technology. The communication loop is affected by the technology, which determines things like the quality of audio and ability to move hands and do gestures. This also ties to people's ability to use the technology. A prime example for this, an example of probably the heaviest issue with most consequences, is echo and poor audio quality. The users can have sounds "leaking" from their speaker to the microphone creating an echo, meaning other users can hear their own voice from a player's mic. This can be a real issue when multiple users talk around such a "leak" as the echoes build up and make discussions impossible. If the user that is creating the echo doesn't know how to fix the issue, the other users can mute them, thus fixing the problem for themselves. But as is apparent, this leaves the person muted out of the discussion and rejected.
This rejection and the feeling of it can start also from the fact that a user might not realise their mic is not working. A certain user was an example of this, a floating head that kept hovering around me and the other users like he would be a part of the discussion. After a while he sent me a message about his mic not working. That took several minutes however. Therefore, the technology can have a big effect on people's ability to build rapport and get accepted into a discussion.
Another technical issue is the volume of your audio. As you yourself scarcely get direct feedback from your own audio, meaning you don't hear it yourself, it is hard to determine what is a good level. It is also a difficult topic to give feedback on by others. People usually do ask another user to dial down their volume if they are loud, but they only do it so many times. After 3-5 times the topic is given up on, which may result in people muting the loud person if they did not manage to fix the problem, or going somewhere else with their discussion.

There are a lot of situations that would be quite unacceptable in regular situa-

tions, especially when it comes to ignoring people. The prior examples on technology issues create a culture where it is ok to ignore others if they don't meet your standards, often determined by the technology they use. As physical properties are determined by avatar choices, which are limited and give rather scarce ability to create an actually unique identity, the technology can have a great impact in how well are you able to create your characteristics and convey them inside a VR system.
On the other hand outside of the technology provided the Altspace, and Recroom too, create a rather equal environment. avatars are fairly similar in height, shape, facial expressions and other features. Therefore it is hard to personalize your interactive elements and communication. There is scarce information on who you are talking to. This alters the context of communication, as you are lacking information that is relevant for the interaction. It alters the communication, not giving full information on other users. This is a double edged sword as it covers racial traits and other characteristics like age and gender that might be used to determine ones character before initializing a discussion. However it also creates a rather equal and open minded communication environment as people have a harder time being prejudice against other people based on external factors.
The similarity also makes it hard to actually know a person, as you only know a filtered version. The evaluation criteria is completely provided by the user and the person you are interacting with has almost full control on what you know about them. This is an empowering feature, which is probably why VR is used so much as a social interaction platform, as it provides a tinge more protection/control in social interaction. Yet it also limits out a great flow of unintentional information that one might convey about their emotion and state, as posture and other details on ones looks are hidden.

Disposition. While exploring the "Ori amusement park" environment with another user I noticed there are many issues with positioning in relation to another user and keeping track of their movement and location. As we moved around and our attention moved from one another to the world and back there were many situations where the other person was not located in the place they previously were. Even if a person is standing right next to you, there is no way of knowing that if they don't stand in your field of vision. And what is completely flipped is the fact that if the person gets too close, they vanish. Therefore rather than having more sensory information from them, you lose what you already had. Even spatial audio doesn't help you locate a user if they are too close to you, as it is not accurate enough.

We ran over the edge of the amusement park with the other user and noticed floating cars, virtual towers and animals around the main island. We also looked at the surrounding artwork that was in the horizon. Due to not having any land beneath us and at times moving very far away from the other game objects, it was hard to measure distance. Therefore, there were many situations where we drifted outside of each other's audio "proximity", out of range for the other to hear the other. Therefore there were multiple situations where we turned our heads looking for the other and asked loudly "where are you?" followed by a "there you are" when the other user was located. This was much due to teleporting and little feedback on the other player's movement, as there is not any audio or haptic feedback. The teleportation is also such a quick method of movement that the other person moves outside of audio range in an instant. This lack of feedback is hard to adapt to as it would require a rather unusual discourse on tracking the other players movement and location through verbal communication constantly.

Back to the ”familiarity with the technology” -issue. This time the VR environment knowledge level. I believe that me having spent so much time in the Altspace Spring Campfire environment has altered my role in that virtual space. This was highly apparent as I asked Julie to join me at the xylophone as I wanted to show that to her. This kind of interaction would not have been possible if I would not be familiar with the space. Same goes with the hardware features. As people can have issues with audio or controls it is often determined by the level of knowledge which kinds of roles get established. The users with the knowledge can become teachers and give instructions whereas other new players remain as observers. Therefore, roles can be determined by prior knowledge.

1.6.2019

AltspaceVR

Signing frustration hand up and down heavily, clear frustration. A user was trying to communicate something to me in the "Space shuttle" environment, but I could not understand him. He then came up close to me and started grabbing my avatar, which I then confronted. He nodded to indicate that he was indeed doing that.
Sign language is kind of weak, only very basic symbols and interactions. Mostly

pointing to refer to objects in the world. Abstract things cannot really be referred to non-verbally.

Going away, turning to look. clear follow, even mute. teleportation easy to lose track of. A user was signing me to follow them and then teleported away, turned around and made sure I was following. That was a very clear message and needed, as teleportation makes it easy for users to lose track of one another.

Walls don't disturb sound. hard to define where sound is from when no visual. I heard some user singing behind a wall and as I talked to them, they fell silent. It was hard for me to find them and therefore I wanted to indicate I heard them and was in the proximity. They then fell silent and I lost track of them. Would this indicate that virtual spaces themselves don't imply social presence with others and the regular norms associated with that? Users seem to be rather ignorant to the presence of others if they do not seem active, if they are mute or if they are not actively interacting with you.

Very free, vapautunut, discussion when other person is not active (fully). Social presence stronger with audio, no messing around. singing guy stoppåed when I talked to them from behind a wal,m awareness of others.

NPC hand on table lean. Very realistic, Yet not done by actual users as there is no feedback. An example on how interaction seems rather real from the third person view.

teleport precision, not always right on place, elevator and car at amusement. I've had a hard time at points to pinpoint my location precisely when I'm on top of objects or even in a discussion circle. It is part to therefore position with the teleportation and I've felt rather embarrased at times if I've mistakenly teleported too close to someone or in the middle of the circle, merely because I did not really land to the spot the teleportation indicator showed.

Name above door, walk through to activate, no teleportation indication.

People don't mind the presence of outsiders. Social presence not that strong. People talking about their personal life just like that. Someone was talking about someone try hitting on them. dramatic sound, very agitated.

Others join the topic another group was talking about. That was a duo talking

about mosquitoes and a conversation on mosquitoes then starting near them between other people.

"On a list". Helper status. A user explained to me what the pink frame on a user meant. This meant helper status, which you get by being active on Altspace. He said you have to fulfill things from a list and gestured that list by holding a hand up and gesturing items on that list with the other.

There seems to be some users that visit Altspace repeatedly. I did not feel any easier to talk to them however, even if I recognize their usernames.

Messaging availability, lonely user grabbing the air is using UI? It is quite hard to distinguish between users who is active and available for discussions and who is not. People move around and mostly try to look busy, which makes it hard to recognise idle, but available people from idle but unavailable. An administrator user for example was doing something on his computer in the real world (based on the sounds I heard) and was not really available for discussion at that moment. However, I didn't really have any possibility to know that.

Bubble makes people vanish, harder to keep track. This referring to earlier notes about disposition and keeping track on people right next to you. It is hard to lose a person if they walk into you, as you might turn and they might teleport out etc. It sometimes happens even during discussions (possibly due to the imprecise teleportation) and is quite disruptive to the flow and momentum of a discussion. It is also common when two users are faced to the same way to look at some virtual object and therefore stand next to each other rather then faced to one another. Because of little indication on the close proximity of another user it is hard to feel their presence there.

rock paper scissors. We played rock paper scissors with a user, agreeing on the different states according to the hand gestures we were able to make with our controllers (paper and rock, plus the thumb up pointer for scissors).
Sign language, camera, heart, rock, paper scissor, counting.
Dramatic pose, hand on forehead.
Playing bass, batting stick to hand.
Mute vs talking, avatar choices.

Crowded, no actual conversation because of overhearing, no 101 discussions. When too much people, not much conversation. Actual talks happen a bit off

others. People don't seem to be completely comfortable discussing freely when other clearly active players are around. I believe it is also quite hard to approach people in large crowds as it is hard to get any info about other players merely based on their avatars. One can't get any info on basic demographics (as observed earlier) and can't even indicate whether a person has their mic on or not. Therefore evaluating the fit for a discussion partner is hard, which might affect people's willingness to interact with one another.

Firecrackers, xylophone. Kind of "beer in hand" alternative. Interaction. Users expect having something to interact around to build rapport, they do not do that all by themselves. These interactive elements also give users something to play with in lulls in speech and conversations and give them as escape from negative conversations. It might also give a possibility for non-verbal indication towards others in order to show what kind of a person you are without starting a conversation.

A user did not want to friend another "before I get to know you." There was indeed a threshold level there.

Just a few features, not much to be done yet in VR to give the environment so much features that users can rely merely on that to build rapport. They still need to be willing to push that interaction themselves. Conversations get initialized rather slowly at times as there is no real reason for choosing a specific person to talk with.

Musician event.

Freeze would be nice on crowd, having a possibility to do something without others noticing. Being invisible in a crowd is important.

Portal was rude, got dealt with. A user opened a portal in the rather small space with the musician meetup.

Lot of observers, inactive. Really cool idea though. People did not get that warmed up by the beginning and the athmosphere stayed quite chilly.

Cup of coffee, laugh. Real life brought into the virtual, setting the space up in a familiar way to make people comfortable. How well does that familiar thing fit into the virtual world, such as providing snacks. Does not work quite as well as

sharing audio, which is actually a great thing to share with others in VR.
Sharing things in VR.

Microphone boosts sound. otherwise sound can be disruptive.

Whispering is hard. Sounds clutter. There is definitely a huge problem with these kind of small spaces with multiple people that are intended to share interests. Having a possibility to vanish to some other, sound proofed, space with a friend or another user to mingle with a smaller group would be great, as people do not enjoy taking too big of a role in a situation like that, the musician meetup where there were up to 15 people and people were supposed to share their interests. The people need a lot more set up on what is appropriate and how to go about stuff. Very little initiative on participants, a lot of observers.

Larger space so that people can spread into multiple conversations. The small space makes anyone talking take over the whole space. It is a real pity as it seems that VR still suffers from the same problem as video conferencing: only one person being able to talk at once without disturbing others. Spatial audio needs to be of insane quality to reach real life standards.

Getting together, streaming live. playing together to play live. jamming together. The musician meetup is a great idea as the virtual get together did feel like people getting together. As audio is one of the least filtered communication tools users have, and the most personal one it is a nice opportunity. People can set up their instruments and play together, if network delay issues can be covered.

pointing again a substituting message.

As speaking would've been rather disruptive in the small space, agreement, active agreement, was rather indicated through nods.

Music sharing live needs quite set up.
Loud mic definitely takes over.

This was the last observation session.