Does the Metaverse live up to its expectations?

A comparative study on team productivity and communication quality in VR and VC.

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Abstract

Research on virtual teams has proliferated since the rise of new communication technologies that allow teams to communicate independent of time and space, with numerous studies highlighting their potential to improve team productivity and communication quality. However, up to now, little research has investigated how virtual reality (VR) may support virtual team performance and communication. Compared to other virtual team technologies, such as video conferencing (VC), VR offers an immersive world, more interactive collaboration tools, heightened feelings of social presence, and the benefits of avatar-mediated communication. To address the knowledge gap, this study aims to investigate whether team productivity (divided into the sub-constructs creative performance and perceived productivity) and communication quality were higher within teams using VR compared to VC, as well as whether this effect is mediated by social presence, immersion, and anonymity. A mixed-methods approach consisting of twelve expert interviews in addition to an experiment with eighty-four employees was conducted. The results show lower levels of perceived productivity and communication quality in VR compared to VC. However, creative performance levels were observed to be higher in a VR setting, implying that VR in the workplace provides potential for the future in specific scenarios and could foster a creative environment. This study was performed in collaboration with DEPT®.

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Introduction

As the world becomes more digitized, various stakeholders including businesses, government organizations, and individuals have found an increasing interest in improving digital capabilities in the workplace, resulting in a shift away from traditional work environments. Traditional offices and physical spaces are transformed into virtual workplaces, and work is increasingly virtualized (Sánchez, 2017). Virtual workplaces, as defined by Garro-Abarca et al. (2021), allow teams to collaborate from divergent physical locations facilitated by the use of technology. Due to the rapid acceleration of technological roll-outs since the emergence of the COVID-19 pandemic, where workers were forced to deviate from physical to virtual workplaces overnight, the way we work has changed drastically. Notably, in light of the shift, companies have faced challenges in determining if and under which circumstances technology-supported teamwork may be effective.

Heretofore an element of imagination and sci-fi movies, virtual reality (VR) has taken the world of work by storm (Castelvecchi, 2016). VR has paved the way for a new way of collaborating in a manner unprecedented in 2D environments such as video conferencing (VC). Cipresso et al. (2018) define VR in terms of three prevailing features: immersion (the stimulated senses and degree of realism), social presence (the psychological feeling of "being there"), and increased possibilities for interaction. With the rise of low-cost VR, companies have taken an abiding interest in its benefits in the workplace. The acquisition of Oculus by Mark Zuckerberg sparked particular interest in VR, with many other multinational corporations, such as Sony, Samsung, and Google following in his footsteps and investing a significant budget in the technology (Castelvecchi, 2016). Companies have also leveraged the opportunities presented by the Metaverse, a collective virtual realm in which users can interact with each other. Within the Metaverse, the application of VR has facilitated the integration of 3D immersive virtual spaces, which enable employees to engage in collaborative experiences in a shared digital environment (Hawkins, 2022).

Particularly since the COVID-19 crisis and the resulting shift towards virtual work, the scientific community has evinced a strong curiosity in the field of virtual work. Among the factors studied within virtual teams, the research on team productivity and communication quality are some of the most prominent. In general, the research suggests that the implementation of virtual workplaces tends to foster an increase in both team productivity and the quality of

communication within teams. In their research, Attaran et al. (2019) recognized digital workplaces as a tool to optimize employee productivity. Amongst many other advantages, they synthesized that by implementing the right digital technology solutions, such as VC and chat-based communication in a workplace, productivity (in terms of reduced time and increased efficiency) can drastically improve. Kock and Lynn (2012) and Maynard et al. (2012) further strengthen this narrative, stating that combining various forms of electronic communication leads to higher team productivity levels. The findings by Jarrahi and Sawyer (2013) also point toward the notion that the enhanced use of information and communication technologies (ICTs) in the workplace leads to higher levels of productivity among employees.

Several studies suggest that VR may support virtual teams' productivity and communication quality. Aufegger and Elliott-Deflo (2022) measured productivity in employees working with VR, finding that teams using VR in the workplace have higher team productivity levels (in terms of both evaluation by a third party and collective task duties with peers) than teams using VC. Numerous underlying factors influencing the levels of team productivity and communication in VR have been identified. Li et al. (2019) explain how the immersive nature of the shared environment in VR can lead to fewer distractions, which may stimulate creative performance and perceived productivity. The variety of tools found in collaborative 3D environments, along with the use of avatars, have also been found to contribute to team productivity levels (Aufegger & Elliott-Deflo, 2022; Ide et al., 2020). Due to the similarity in communication modalities between VR and a face-to-face setting, communication quality appears to be enhanced in VR over VC. Furthermore, communication mediated by avatars in VR offers the ability to convey social cues, which may improve overall communication quality (Maloney et al., 2020). Lastly, the associated higher levels of social presence and immersion in VR may help boost team productivity levels and communication quality in virtual teams.

Despite the vast amount of literature on the topic, little light has been shed on team productivity and communication quality concerning VR and VC. Thus, the main goal of this study is to assess the effect of different virtual workplace technologies (VR vs. VC) on team productivity levels and communication quality in a corporate setting using a mixed-methods approach. First, we will interview experts in the field to gain insights into contemporary thinking on the future of the workplace and VR, and assess how virtual workplaces can impact productivity and communication. Next, an experiment investigating the effect of the difference

between the technologies on multiple factors will allow an in-depth analysis of which underlying factors influence productivity and communication, testing the constructed hypotheses. The results will be of aid to companies interested in enhancing creative performance and communication quality in their virtual teams, providing potential directions of virtual workplace strategies as well as accentuating the importance and opportunities that the technology has to offer. The findings will further be of significance to the larger scientific community, adding to the body of knowledge around the different factors of how virtual teams work. They will also contribute to the gap of research in the effects of different contextual dimensions of virtual work on team productivity, communication quality, and their underlying factors. The present study was conducted in collaboration with DEPT®, a leading global digital agency at the intersection of technology and marketing.

The following research questions serve as a fundamental basis for the study at hand:

> *RQ1:* How do professionals see the advantages and disadvantages, as well as the role and future of VR compared to VC in the workplace?
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> *RQ2:* How does the difference between teams using virtual reality (VR) and teams using video conferencing (VC) in the workplace influence team productivity and communication quality in employees?

Theoretical Framework

Virtual Teams

Utilizing a wide variety of electronic technologies, such as email and VC, virtual teams are often geographically dispersed groups that collaborate virtually (Guo et al., 2009). Remote work allows for virtual teams to collaborate regardless of the time and location of individual team members, offering higher flexibility than traditional, in-office teams. However, certain drawbacks have also been identified. Collaboration might be impaired due to the feeling of distance from other team members. Drawbacks such as loss of interest, lower engagement, and participation rates in collaborative projects have been highlighted by Topaloglu and Anac (2021). These disadvantages draw attention to the essentiality of platforms that offer virtual teams the

opportunity to collaborate and communicate with each other effectively. Video conferencing is one such tool that has gained increasing prominence in recent years (Riedl, 2021).

Video Conferencing

Video conferencing (VC) can be understood as the use of web-based tools such as Zoom, Microsoft Teams, and Google Meet to connect two or more parties live and virtually, regardless of their geographical location. Dating back to the 1960s, when the first prototypes emerged, VC tools have evolved into popular cost- and user-friendly platforms (Riedl, 2021). The pandemic helped accelerate the adoption rates of new virtual technology tools (Costello & Rimol, 2020), leading them to be incorporated into many people's daily lives. Amongst the several new adopters, virtual teams have increasingly taken to conducting meetings and collaborating in a remote setting.

Compared to more traditional methods of communication and collaboration in the workplace, such as phone and email, VC offers a multitude of advantages. For one, it allows for synchronous communication, in which users can leverage the ability to portray factors such as attitudes and nonverbal communication (Abdullah et al., 2021). Thus, it gives the option for employees to communicate with each other in real time whilst being in different locations, granting more flexibility and freedom. An additional benefit is the availability of a plethora of tools that are specifically designed to enhance the effectiveness of team meetings, such as the ability to generate polls, share one's screen to project content, and interact via chat (Karl et al., 2021). While VC offers many advantages, it has also presented certain obstacles and challenges for employees in their utilization.

Coined as the term zoom fatigue, a phenomenon has emerged in which employees feel anxious and tired as a result of excessive use of VC tools such as Zoom. In general, it encompasses the psychological fatigue that arises as a cause of prolonged exposure to meetings in VC (Deniz et al., 2022). Several causes of the phenomena have been identified, one of which is associated with overstimulation and enhanced cognitive effort in the brain due to continuous exposure to visual stimuli (Federman, 2006). Bailenson (2021) explains that due to the nature of certain characteristics in VC systems (such as prolonged gaze at close proximity, artificially sized faces, and constant self-view), a cognitive overload occurs that in turn results in the sense of fatigue in users. Another cause of the phenomenon is linked to the lack of body language

(Meeren et al., 2005), particularly the limitation of only seeing the counterparty's face instead of their full body, which can impact the perception of emotions. Thus, the emergence of factors such as the limited nonverbal cues, social isolation, and psychological fatigue, highlights the importance of designing a virtual workplace that promotes employee well-being and performance. This has led stakeholders to explore alternative technologies such as virtual reality, which have the potential to address these limitations and create more immersive and interactive virtual environments.

Virtual Reality

Dating back to the mid-1960s, when the initial discovery and thoughts of the possibility of immersing oneself into a new virtual world emerged, the term virtual reality (VR) was inaugurated in a pioneering manuscript written by Sutherland (1965). The technology promised to offer a new dimension of reality in which one can be anywhere and anyone. It utilizes cutting-edge technologies to replicate a three-dimensional (3D) virtual realm that responds to the user's movements, thus enabling a highly immersive and authentic experience (Fuchs & Bishop, 1992). Several definitions vis-à-vis the technology have emerged, the majority of which highlight the inclusion of three vital features: immersion, presence, and interaction (Cipresso et al., 2018). Immersion is the technology-enabled process that allows an individual to experience a virtual environment as if it were real (Slater & Wilbur, 1997). Slater and Sanchez-Vives (2016) state that a VR system (such as a Head Mounted Display (HMD)) has the potential to place an individual into a 3D environment through a display system that leads a user to undergo a perceived feeling of transportation into a virtual environment (VE). An immersive experience in VR allows the user to forget about their real-world surroundings and fully engage with the VE. Second, presence is defined as the user's perception of the degree of realism within an environment or a sense of being in a real-world setting. Presence in VR is vital as it leads the user to a more authentic and interactive experience in which they feel physically present in the virtual world (Hauber et al., 2006). Tying into the sense of presence is the level of interaction with the environment, which Cipresso et al. (2018) explain encompasses the active engagement and manipulation of objects and elements in the virtual world. They posit that the ability to engage in more realistic interactions within a VR environment leads to a heightened sense of presence and immersion for users.

Among the various forms of VR, HMDs have emerged as the most prevalent, providing users with a fully immersive experience through the use of stereoscopic viewing and audio technology within the headset (Cipresso et al., 2018). Additionally, VR can consist of a semi-immersive (where users experience the same virtual world while still being aware of their physical surroundings) and a non-immersive (2D environments without immersion) experience. The current study centers on HMDs, which project two-dimensional images on each corresponding eye through a mounted display. Paired with motion and gaze tracking capabilities, the device can capture the orientation of the user's eyes and head to process this information and subsequently adjust the projected images according to a user's viewpoint. This process allows for the creation of a VE in which the user is projected into a life-sized world as their movements are tracked and adjusted to the 3D world around them. As Slater and Sanchez-Vives (2016) depict it, what differentiates VR from other formats of human-computer interactions is that the human engages in the virtual world as opposed to simply using it.

The past decade has brought about the proliferation of low-cost HMDs, thereby making the technology more widely accessible to the commercial sector (Dzardanova et al., 2021). In a study by Aufegger and Elliott-Deflo (2022), VR was shown to benefit employees by offering the possibility of a shared office space. This aspect promoted the facilitation of collaboration in teams to align on projects in an effective manner as well as share content with everyone present. Another benefit associated with VR entails its personalization feature. Users can flexibly tweak the design, decorations as well as their personal avatars to their liking. Research by Biener et al. (2022) showed that this characteristic led to higher satisfaction in employees and a greater experience in the collaborative workspace. An additional noteworthy advantage of VR is the capability to provide an immersive experience. As Mütterlein et al. (2018) noted, VR enables the creation of a simulated environment in which individuals can engage in social interactions and perceive the presence of others through life-size avatars, promoting a sense of cohesion and closeness within a collaborative virtual reality setting. Potential drawbacks of VR, such as the device's weight and levels of comfort, were identified by Aufegger and Elliott-Deflo (2022). Participants of their study expressed concern about the heaviness of the HMD headsets and discomfort after having worn them for a longer period. Biener et al. (2022) present their findings on the negative effects associated with the prolonged use of HMDs, including simulator sickness and self-rated task load. Despite some limitations, the beneficial qualities such as the immersive

environment and presence enabled by VR may positively affect creative performance and communication.

Creative performance

The art of being productive, as defined by Tangen (2002), is the quantifiable ratio between input and output combined with the comprehension of how a business utilizes resources to reach the firm's targets (Diewert, 1992). Within organizations, productivity is seen as an important factor that contributes to the internal success and financial prosperity of the company (Aufegger & Elliott-Deflo, 2022).

Productivity can be decomposed into various sub-constructs, one of which is the creative output of ideas, namely creative performance. As described by Amabile (1996), creative performance is the process of producing novel insights and ideas. This construct can further be partitioned into fluency (the number of relevant ideas developed), originality (the uniqueness of the ideas), and flexibility (breadth of categories of ideas) (Guildford, 1967). As articulated by Ferreira et al. (2020), firms are seeking new ways to promote creative performance in employees to leverage its benefits of creating a competitive advantage. In today's age of artificial intelligence and automation, Anderson et al. (2014) emphasize the importance of creative performance to drive innovation and in turn contribute to organizational performance. They consider creative performance as an important team task as it allows for the generation of new and innovative ideas, which can lead to increased team productivity and success in achieving the team's goals.

The present study hypothesizes that creative performance levels will be higher in VR than in VC. A key element that lends credence to this idea is the reduction of distractions within a VR environment. Due to the immersive nature of collaborative VR spaces, users are less prone to being interrupted or losing focus by physical distractions, which can positively influence the performance of employees. Li et al. (2019) orchestrated an experimental comparison between face-to-face, video, and VR communication and found that due to the blocking of the external environment through the HMDs, users reported fewer distractions than in other conditions, which in turn led to more productive conversations and better team performance. Tenorio-Morales et al. (2020) echoed the results of this finding as their data pointed towards the notion that their VR environment (SyncMeet), compared to Skype, led participants to focus more

on their tasks without being distracted. Additionally, in an experimental study by Ruvimova et al. (2020), the researchers found elevated feelings of focus in participants who conducted a meeting at a virtual beach in the VR condition due to the feeling of being fully immersed and transported without distractions from the physical world. This data indicates that detachment from the physical workplace has the potential to encourage higher focus levels than in VC, which can positively affect creative performance.

The second justification for augmenting creative performance is the wide array of (3D) tools available in VR. In their qualitative study exploring the quality of both individual and team productivity within Meta's Horizon Workrooms (a collaborating 3D VE), Aufegger and Elliott-Deflo (2022) found that better visualization and implementation of tools within the platform (such as content projection) led to the facilitation of alignment within virtual teams. Supporting this claim, Tenorio-Morales et al. (2020) compared a collaborative VR environment with VC (Skype) and concluded that the tools available (such as 3D whiteboards utilized to draw and write) facilitated creative performance in their virtual teams.

Additionally, the use of avatars in a virtual workplace has been found to help facilitate productivity. Ide et al. (2020) orchestrated an idea generation task, in which they compared face-to-face interaction with virtual teams (with and without symbolic gestures). Their findings indicate that participants in the symbolic gesture condition produced the highest number of ideas and fostered a positive environment for virtual idea generation. Avatars were also proven to enable proactive involvement, engagement, and team inclusion, characteristics found to be important in defining performance (Greenwald et al., 2017). These conclusions lead us to propose the following hypothesis:

> *H1a:* Teams using VR in the workplace have higher creative performance levels than teams using VC.

Perceived Productivity

A further sub-construct of productivity relevant to this study is perceived productivity. As indicated by Humphreys and Nicol (2007), perceived productivity encompasses the perception of how productive a team member feels their team has performed in a given task. Self-assessment

of team productivity by an employee can be beneficial because a multitude of tasks performed in office work are not quantifiable and must therefore be evaluated using subjective measures (Meyer et al., 2017).

As argued in the previous paragraph, working in VR forms an environment in which creative performance is stimulated, which can ultimately lead people to think the tasks they perform are more productive. Thus, we argue that perceived productivity will be higher in teams working in VR than in VC. As demonstrated in an observational study by Aufegger and Elliott-Deflo (2022), working in a VR setting was instrumental in enhancing levels of perceived productivity through its ability to reduce distractions and provide a concentrated work setting compared to traditional VC methods. Further, the available tools and use of avatars in VR constitute enhanced creative performance levels and in turn perceived productivity levels (Tenorio-Morales et al., 2020; Ide et al., 2020). These reasons lead us to pose the following hypothesis:

> *H1b:* Teams using VR in the workplace have higher perceived productivity levels than teams using VC.

Communication

Communication is the process of the transfer of information and comprehension between several parties and is vital for teams to collaborate (Lilian, 2014). Wei et al. (2022) conducted a systematic review on communication in immersive social VR, highlighting the importance of communication as a means to build relationships, resolve issues and connect team members. Bhat et al. (2017) further underline the importance of communication in virtual teams because it acts as a vital tool for teams to collaborate productively.

Computer-mediated communication (CMC) encompasses the various forms of digital communication that are facilitated through technology. Types of CMC include text only, video only, and a combination of both. CMC offers flexibility for team members to communicate and share content regardless of their geographical location. However, it provides only a limited ability to convey nonverbal cues. The absence of nonverbal communication (such as direct eye contact or body language) makes understanding and communicating complex and emotional

information harder, as these types of communication require more bandwidth and a variety of channels to communicate effectively (Daft & Lengel, 1986; Gressgård, 2010).

CMC offers less qualitative interactions than face-to-face communication, tying into the medium-richness theory (MRT) established by Daft and Lengel (1986), who argue that performance is dependent on the suitability of a medium's information richness to task information. The media synchronicity theory (MST) by Dennis and Valacich (1999) explains the MRT according to the synchronicity of communication. The theory posits that media synchronicity acts as a predictor of communication effectiveness and argues that the enhancement of communication can occur should the synchronicity of a media align with the synchronicity level necessary for the task. Synchronicity entails the degree to which individuals can simultaneously work on the same task. Low synchronicity media (such as e-mails or chat-based messages) are typically preferred for the conveyance process, as the user has more time to process and understand the information. Conveyance refers to information transfer of task-related information, such as task information, schedules, and project planning. High synchronicity media (such as VC and VR) are more suitable for the convergence process. Convergence processes are communication tasks that require team discussion and shared understanding among team members, such as negotiation, group discussions, or creative team tasks.

Compared to VC, VR offers several characteristics that may enhance convergence in team interactions. First, VR systems provide the possibility of adding additional symbols compared to VC. It can be argued that VR boasts a wide array of social cues made possible through avatar-mediated communication (AMC), such as the ability to whisper to the person next to you or follow a user's eye gaze (Maloney et al., 2020). On top of synchronous verbal, textual, and visual communication, AMC additionally presents the opportunity to incorporate physical communication, such as handshakes or touches on the shoulder. These social cues can amplify the meaning of the message and enhance shared understanding within virtual teams (Dennis et al., 2008), offering support for our prediction that communication quality will be higher in VR than in VC.

Further attributes concerning the predicted higher levels of communication in VR have been found in previous studies. Upon conducting a comparison of the results of a collaborative task conducted in face-to-face, VC and VR, Tenorio-Morales et al. (2020) concluded that VR

facilitated information sharing compared to VC due to its similarity to a face-to-face environment. Another prominent application of VR contributing to the quality of communication entails the ability to draw in mid-air. In their experimental study testing a virtual cake designing tool in VR, Mei et al. (2021) found that sketching in the air helped participants convey ideas whilst collaborating and led to facilitate communication. Furthermore, as a result of an observational study, Maloney et al. (2020) explain that factors resembling non-verbal behaviors in a face-to-face setting, such as the tracking of body movements, gaze, and facial expressions, allowed for higher levels of communication. Abdullah et al. (2021) reinforce this concept by stating that communication behaviors measured in VR were closely related to those in face-to-face settings rather than in VC, indicating that communication in VR encapsulates higher communication quality than in VC. In sum, VR offers more opportunities for richer interaction and convergence processes than VC. As a result, we expect that communication quality will be higher in the VR setting compared to VC:

> *H2:* Teams using VR in the workplace have higher communication quality than teams using VC.

Social Presence

As defined by Biocca (1997), social presence refers to the feeling of being in a space with a "real" person, thus the degree to which a user feels they are communicating and interacting with another human being as opposed to a computer or other technological device. Hauber et al. (2006) further explain the feeling as a sense of closeness between geographically disparate individuals that emerges through a communication medium. Short et al. (1976) divide the concept into the feeling of intimacy (sense of connectedness) and immediacy (emotional separation), which are dependent on both verbal and nonverbal cues (Gunawardena & Zittle, 1997).

Social presence is expected to be higher in VR than in VC. The construct relies on the ability to convey nonverbal cues, an area in which VR boasts a significant advantage over VC. One main argument in favor of VR is the concept of behavioral realism (the degree to which a virtual representation behaves like a real person) (Oh et al., 2018). Turning towards and moving away from another avatar, proximity-based loudness of others and gestures all contribute to

enhanced behavioral realism (Bailenson et al., 2006). For instance, Hauber et al. (2006) compared social presence in 2D and 3D spatial interfaces, finding a positive influence of 3D VEs on perceived social presence due to heightened gaze awareness. Therefore, in contrast to a VC setting which obstructs the ability for a user to discern the visual focus of their counterpart, VR provides a platform in which this observation can be made possible.

Another differentiating factor found in VR that can help enhance a sense of social presence are depth cues, which allow users to perceive the distance and shape of objects in a VE. A primary driver behind perceived depth are stereoscopic cues, which occur when two slightly different images are presented individually to each eye (Cumming & DeAngelis, 2001). In Kim et al. (2012)'s experimental study assessing the impact of gaze and body posture, they compared two 2D environments (with and without 360-degree motion) with a 3D environment that offered stereoscopic cues. Stereoscopic cues were found to enhance perceived social presence. Echoing the results drawn from the previous study, Ahn et al. (2014) found a positive effect of stereoscopic and human-size displays on social presence compared to monoscopic and small-size displays. Combined with stereoscopic cues, spatial audio and motion parallax (the extent to which the position of objects in VEs move relative to the alteration of a user's movements) have been demonstrated to augment the number of depth cues in VR compared to VC (Gerig et al., 2018; Vienne et al., 2020). In turn, depth cues have been shown to enhance feelings of social presence (Oh et al., 2018). Based on the aforementioned findings, we propose the following hypothesis:

> *H3a:* Teams using VR in the workplace experience a higher degree of social presence than teams using VC.

We also expect social presence in virtual teams to enhance team productivity and communication quality. AMC allows for interactions from the first-person perspective, enhancing the feeling of social presence, which ultimately leads users to feel closer to their peers and elevates the feeling of community in virtual teams. This social bond is a prerequisite for both quality communication and creative performance (Leana & Van Buren, 1999). Enhancing this finding, Oh et al. (2018) conducted a systematic review on social presence, in which they

underline the importance of social presence in virtual environments as it has been proven to heighten communication outcomes through the underlying influence of factors such as trust and enjoyment. Greenwald et al. (2017) conducted an experiment in which they compared the outcome of tasks performed in VR vs. face-to-face and investigated how the feeling of social presence ties into said difference. Their findings indicated that participants in the VR condition reported not only higher levels of the feeling of social presence but also higher levels of perceived effective communication and increased efficiency in solving a collaborative task. Thus, the following hypotheses are formulated:

> *H3b:* A positive relationship exists between the extent to which team members experience social presence and the team productivity levels.
> *H3c:* A positive relationship exists between the extent to which team members experience social presence and the communication quality of teams.

Immersion

Conceptually, immersion can be described as the act of using technology to transport an individual from a physical to a virtual environment (Slater & Wilbur, 1997). Weiss and Jessel (1998) further state that immersion within VR occurs when the user is disconnected from the real world and fully immersed in the virtual one. Immersion characterizes an essential factor of VR, as the aim of the technology is to replicate and substitute physical, sensory perceptions (such as visual and auditory) of the real world with ones generated in a VE. Higher senses of immersion are associated with the advanced technological abilities of VR systems. For instance, a VR system offering a 360-degree high-resolution projection coupled with low latency regarding the responsiveness of body, head, and eye movements offers a more immersive experience than a system with less or lower quality capabilities. These technical details then lead to a higher probability of succeeding in substituting sensory perceptions (Slater & Sanchez-Vives, 2016).

We expect immersion to be higher in VR than in VC for several reasons. The nature of immersive 3D VR systems such as HMDs offer more sensory perceptions that lead to an elevated feeling of being in the virtual world, compared to traditional VC technologies. Technologies associated with VR systems (such as 360-degree displays) allow for a more realistic and detailed VE to be constructed, which ultimately leads to a more immersive experience. As observed in

the comparative studies on VR and VC by Tenorio-Morales et al. (2020) and Ruvimova et al. (2020), participants felt detached from the physical world and more immersed. These findings further support the notion that VR stimulates an environment in which users perceive higher levels of immersion than VC.

Additionally, controllers and hand-tracking facilitate the ability to conduct actions like drawing, moving objects, or "touching" others' avatars and depict realistic gestures in a VE. Control over avatars to perform gestures such as high-fiving a teammate led participants to report a more immersive and rewarding social experience in social VR compared to virtual worlds on networked computers (Maloney et al., 2020).

Lastly, the use of avatars in a first-person perspective in VEs constitutes a sense of embodiment associated with a higher sense of immersion. The qualitative study by Maloney et al. (2020) discovered that participants mentioned that the application of full body tracking in a social VR setting led them to perceive their movements as an avatar of an actual person due to the ability of the technology to "mirror" their physical bodies. They found that these embodied interactions led to greater awareness of body ownership, which enhanced participants' sense of immersion. In their pilot study assessing the differences between VR and VC, Steinicke et al. (2020) found significantly higher levels of immersion in VR than in VC, leading us to form the following hypothesis:

> *H4a:* Teams using VR in the workplace experience a higher degree of immersion than teams using VC.

Furthermore, we predict that immersion will positively affect team productivity levels within virtual teams. For one, this can be attributed to the flow state a user is prone to enter when immersed in a virtual world. Flow is described as the natural state a person enters when they are fully immersed and can devote their undivided attention to the task at hand (Csikszentmihalyi, 2008). A high level of flow state contributes to a person's creative performance (Pacauskas & Rajala, 2017).

Also, immersion was attributed to higher creative performance levels in a brainstorming activity in VR compared to traditional communication methods like Zoom or Skype. Participants in Kut'ák et al. (2019)'s study stated they were able to focus better and maintain their attention

spans longer, which altered their cognition during the idea generation phase. Additionally, the results of the collaborative brainstorming task by Tenorio-Morales et al. (2020) showed that the immersive and playful nature of the VR environment not only contributed to participants' concentration and engagement levels but also facilitated information sharing and understanding, which ultimately led to a high perception of collaboration effectiveness. Li et al. (2019) and Ruvimova et al. (2020) reinforced this idea by asserting that through the sense of immersion and full transportation to the VE, participants were able to enhance their creative performance levels as they were less distracted from their tasks. The following hypothesis is thus introduced:

> *H4b:* A positive relationship exists between the extent to which team members experience immersion and the team productivity levels.

Lastly, we also hypothesize that immersion in virtual team members will positively affect communication quality. For one, with the use of AMC, nonverbal communication is more familiar and natural, and body language embodied as an avatar can lead to more effective communication. Full body tracking allowed for an accurate and more intimate depiction of emotions, which led to facilitated ways of expression and understanding (Maloney et al., 2020). Developed by Kock (2014), the media naturalness theory entails the notion that face-to-face communication is more natural than any other medium. In order to reach the same level of face-to-face communication, certain criteria must be met: colocation (visible and audible cues), synchronicity, ability to portray facial expressions and body language as well to transmit language. AMC allows for facial expressions and body language of avatars, leading to communication that is perceived as more natural, which helps a user to enter a state in which the awareness of technology reduces and the focus is laid more on experience. For instance, in an experimental study by Mütterlein et al. (2018), in which they assessed cooperation in VR through a collaborative VR experience, their findings provide support to attribute elevated intentions of team members to collaborate to the feeling of immersion. HMDs can also enhance social interactions with other users in virtual environments, providing support for the last hypothesis:

H4c: A positive relationship exists between the extent to which team members experience immersion and the communication quality of teams.

Study Setup

This study applied a mixed-methods approach and was conducted in two phases. In the first step, in order to gather insights and explore the underlying factors present when working in VR, twelve semi-structured expert interviews were conducted. Based on the results found, an experiment comparing team productivity, communication quality and their underlying factors in VR and VC was performed. A detailed overview of the methodology applied is introduced in the following section. This experiment was conducted in accordance with the rules & guidelines of the Research Ethics and Data Management Committee of the Tilburg School of Humanities and Digital Science.

Study 1 - Method

In an effort to examine the potential underlying factors influencing team productivity and communication quality as well as to investigate the potential of VR in the workplace, twelve semi-structured interviews were performed. The interview questionnaire in its full length can be found in Appendix A. Throughout the interviews, participants were able to share their insights on the topic at hand and elaborate on their personal visions, offering an in-depth understanding of how VR ties into the workplace and how it is projected to develop in the future.

Participants

Participants for this study were approached personally by the researcher via Slack or e-mail and asked to meet virtually in October 2022. Once they agreed to their participation, a thirty-minute time slot via Google Meet was arranged. The criteria applied to be able to participate in this study were the following: previous work experience in the field of VR and Augmented Reality (AR) and proficiency in the English language. A total of twelve semi-structured interviews with participants from a spectrum of positions within and outside of DEPT® were conducted. An overview of the participants' occupations can be found in Appendix B.

Procedure

Prior to the study, participants were informed of the topic of the interview via email or Slack. Before starting the interview, the researcher presented the general goals and topic of the study and asked for verbal informed consent as well as if the video call could be recorded. The participant was then also informed about the applicable data policies (i.e., the right to removal and insight of data at any given time, guaranteed confidentiality and anonymity, and data storage according to GDPR guidelines). As soon as the participant provided their consent, the interview could start. It started off with general questions on their current position and previous experiences with VR before elaborating on the details of their thoughts on the future of the technology. After all the topics had been covered, the interviewee was thanked and able to leave the call.

Study 1 - Results

Several findings consisting of different themes emerged from the interviews. They have been divided into: enhancing team productivity and communication quality in VR, underlying factors of team productivity and communication quality in VR, and the future and potential of the virtual workplace.

Enhancing team productivity and communication in VR

The first topic of interest was the potential to enhance team productivity and communication quality in VR. Several of the participants who had used virtual collaboration spaces in VR prior to the interview commented on its promising potential.

> We had this even before the pandemic that teams from different countries needed to work together and there was a lack of communication and identification amongst them - this is something that we can hopefully solve with this sort of technology. (Participant 1)

> I think once you're in there, some of the distractions around you in the physical world just disappear. (Participant 6)

> I think that the ability to be in a world where presence is as closely replicated as the real thing, it's gonna make for more impactful and meaningful experiences and, as far as work collaboration goes, more productive experiences. (Participant 10)

It was noted that VR bridges the gap between teams and working on joint projects more collaboratively and effectively by enhancing the feeling of being able to explain oneself and elevating the visibility of shared content. Additionally, participants noted that VR is more beneficial for team collaboration. In VC, everybody needs to wait their turn to speak, whereas VR is more interactive. However, the general notion was that it is not productive to wear a headset and work in VR all day - the devices are too uncomfortable and heavy and will not lead to a productive experience over a prolonged time. Functionally, VR is just not a critical tool outside of very specific use cases. However, for collaborative scenarios, such as project kick-offs, there could be benefits. Users can be in the virtual space together and feel like they can collaborate easily with others. Therefore, ideas may be more easily shared and people are able to gauge each other's reactions to their team members' input. Teams can meet in the same space and experience the same environment as their peers, which can enhance collaboration and bonding.

Underlying factors of team productivity and communication quality in VR

In order to closely investigate the underlying characteristics of team productivity and communication quality in VR, participants were asked to utter their thoughts on which factors they think are the viable determinants thereof.

Immersion

Participants exemplified how immersion can be of use in a virtual environment:

> I think this is one of the main factors which makes it such a great experience and exactly the fact that it differs from web conferences. I think that the immersion bit of the equation is the most crucial one - that you feel confident and you feel like you have a pleasant experience and that you are actually part of it and not watching a video but you become part of the environment and dive

into the situation. I think the immersion itself is the factor why people will be using it more in the future. (Participant 1)

I've played a lot of games, the gaming part is awesome because you actually forget that you're in the game - it's so immersive and you're just emerged into it. I think it could be the same for work if you can solve the problems of note taking and reading other people's faces. (Participant 7)

I think that the immersiveness of VR, especially when combined with the same or better work collaboration tools, is going to, in a very healthy and productive way, create that connection that is going to be more productive than looking at a bunch of squares on a screen. (Participant 10)

Social Presence

Moreover, social presence was also mentioned in regards to the benefits of VR.

I literally felt I was in the room with them after a while (in Horizon Workrooms) - I was moving my hands and they were seeing my hands (even without the controllers), I could see across the room, I could see people move their heads and some facial expressions, the quality of the sound was amazing. We couldn't work together physically and suddenly it felt like tech was solving a problem and getting us closer together. (Participant 2)

I do think that, when you're in those meeting rooms I actually think you make a better personal connection. My friends and I would do VR poker and it felt very natural, I actually felt like "alright I'm actually sitting in a room with you", whereas doing that in Zoom felt super unnatural and I didn't like it. (Participant 6)

There are certain experiences I've had in VR where I think back now and I think it was a real experience, I really feel like I have stood at the top of mount everest. There are interactions that I've had with people that were right in front of me and I feel that they were really there. So, overall I'm really excited about the benefits of a work and collaboration based VR environment. (Participant 10)

An analysis of the participants' responses thus indicates that participants echoed the theoretical findings that immersion and social presence present important measures to enhance team productivity and communication quality in VR due to factors such as the reduction of

physical distractions, the natural feeling and reality of the VE, gestures and personal connections. For instances in which teams need to meet for creative meetings such as brainstorming, collaborative 3D environments open up possibilities of being able to be far more tactile and involved than if the team are all virtually at home.

Anonymity

Besides the factors previously identified through former research on the topic, a number of respondents indicated that the anonymity potentially offered by VR may be of use in a virtual workplace:

> It also gives you the ability to get rid of some biases. People can make themselves look however they want to in a VR world, and sometimes that can help a lot. You suddenly dispel any biases you might have about their ideas because they are able to project themselves in a way that they want to, I think that can really go a long way. So it really becomes more about their ideas and less about how they physically look. (Participant 6)

> The idea of really being able to tailor how you are perceived by the world, that's where there could be a lot of value. For example if you have a group of people who have never met each other before and there's an actual, tangible reason to use VR but they're nervous about meeting people for the first time, they get to wear this veneer that presents to this new group of people what they really want the other people to see in them. (Participant 9)

> Often people enjoy going into these outer world spaces because they can express themselves more freely or feel more open to express themselves. People can be whoever they want to be, they might feel more open, accepted and free. (Participant 12)

Based on these findings, we expect participants to report higher anonymity levels in VR than in VC. Kocur (2022) explains that avatars allow users to adopt a "new identity", opening up the possibility for them to feel a sense of anonymity through the replacement of their true selves. As explained by the participants, avatar-mediated communication (AMC) enables users to tailor how they want to be perceived, a driving force behind the feeling of anonymity. Findings by the participants further propose that, as opposed to traditional encounters in 2D environments (such

as VC) where users can see each other's physical selves through a webcam, the use of avatars in VR creates a new opportunity for users to interact through their customized virtual selves. This act of customization enables participants to project and tweak their virtual identities in the form of an avatar. As this can lead a user to experience a sense of disconnection from their physical self, it can deepen their feeling of anonymity. Thus, based on the results of the interviews, we decided to include anonymity as an additional factor that would explain differences in outcomes between VR and VC. First, we pose that anonymity will be higher in VR than in VC:

> *H5a:* Teams using VR in the workplace experience a higher degree of anonymity than teams using VC.

We further expect anonymity to lead to higher levels of creative performance within virtual teams due to the belief that team members perform better when they feel anonymous. Introduced by Reicher et al. (1995), the Social Identity model of Deindividuation Effects (SIDE) proposes that anonymity leads individuals within teams to divert their attention from distinctions from their peers to the increased salience of a social identity when such an identity is present, which can alter behaviors towards communication and performance. For instance, Le Hénaff et al. (2015) further extended the findings of the SIDE model by concluding that anonymity in VE positively influenced performance in groups. These reported higher levels were attributed to the fact that anonymity reduces the fear of negative evaluation from a teammate and leads to higher perceived self-esteem, which can allow participants to execute tasks and generate ideas without the feared judgment of their performance within the group. As an outcome of the study conducted by Greenwald et al. (2017), they concluded that the interaction between participants in VR led to higher levels of collaboration and focus as they were able to disguise aspects of their physical appearance. A further characteristic mentioned by participants was the reduction of biases and discrimination that occur through the use of avatars in VR. The VE allows for the creation of a safe environment where employees feel more comfortable with sharing their ideas and work more effectively due to the ability to obscure idiosyncratic features. These characteristics lead us to propose the following hypothesis:

H5b: A positive relationship exists between the extent to which team members experience anonymity and the team productivity levels.

Lastly, we anticipate that a heightened sense of anonymity will lead to higher levels of communication quality within virtual teams. As stated in the interviews, anonymity allows users to feel the freedom to express themselves more honestly and openly than in a VC setting, which can lay the groundwork for augmented communication levels. Additionally, it was found that higher levels of anonymity can lead team members to engage in more meaningful and authentic interactions (Wei et al., 2022). A study by Lee (2021) underlines the beneficial effect of anonymity on virtual team collaboration. They found that the quality of knowledge sharing increased in teams working in anonymous VE. Baker et al. (2019) further found that AMC in social VR induced a level of anonymity in participants that led them to share more information and encouraged users with introverted tendencies to more free expression, which helped facilitate the communication between participants. Thus, the following hypothesis is introduced:

H5c: A positive relationship exists between the extent to which virtual team members experience anonymity and the communication quality of virtual teams.

Future and potential of virtual workplace

Lastly, the interviewees shared their thoughts on the evolution of the virtual workplace and their visions of the future.

> We need additional stuff upon Zoom, Meet and Teams and there VR will play a role moving forward - but not today. (Participant 2)

> Will it replace VC? At this moment I don't think so, but if you can really collaborate and be present in the room then I think it could make sense for some use cases. (Participant 8)

> In this world of virtual work, when you're not going and collaborating with your colleagues in person - the future looks incredibly bright. I'm so excited about being able to be anywhere in the world with my colleagues to collaborate on work. (Participant 10)

Generally, virtual teams were found to be highly beneficial to the workplace as employees are still able to prove their benefit to the company, but it does not matter anymore where in the world one is situated. For VR, one of the identified added benefits was that employees can stay at home yet still feel part of the team because virtually, they are all still sitting together in the same room and drawing on the same board. Additionally, 3D environments offer more opportunities than in a 2D space, such as being able to collaborate on a virtual 3D whiteboard jointly. However, the easiest way to go is still VC for regular, short alignments with team members.

Drawbacks of the technology were both physical barriers (devices are uncomfortable and heavy, especially after a prolonged period; lags; motion sickness) and financial (return on investment (ROI) is still unclear for companies, high-cost ventures for a company-wide roll-out, high barrier to entry).

Feasible use cases to implement VR in the workplace were identified by the interviewees as creative-, process- or team-oriented tasks, situations where there are products or services that would benefit from 3D visualization, workshops to introduce clients to the potential of the new technology and replacement of long-distance travel.

Although the results are somewhat mixed, these findings suggest that VR can be beneficial for creative performance and communication quality in some instances. Notably, some suggestions regarding the design of collaborative workplaces in VR were presented: they must be accessible through all devices, more extensive facial expressions and body language should be included as well as more options for customization, higher fidelity when sharing content with others should be given and the inclusion of better productive tools (e.g., Microsoft Office) must be incorporated. Multiple participants stated that augmented reality (AR) has promising outlooks for the future and may surpass VR by providing more effective and user-friendly options. AR allows for an immersive experience without a complete replacement of the whole world and still allows users to “be human”. Concluding, as of present, the advantages of VR in the workplace do not outweigh the disadvantages yet and it would be too big of a shift in how an everyday individual consumes content to implement on a wide-scale basis.

Study 2 - Method

In the second phase, an experiment was conducted to test the differences between team productivity and communication quality within teams working with VC and VR.

Participants

The sample for this experiment consisted of eighty-four employees at DEPT®. The digital agency DEPT® specializes in creating and implementing end-to-end digital solutions for their clients. The employees of the organization act as a well-suited population for the current experiment as they have a deep understanding of and have experimented with technologies available to support virtual teams (such as VR). Additionally, the employees are accustomed to working remotely, as many international teams meet and work together on projects virtually.

To gather participants for the study, the convenience sampling method was applied. The researcher approached employees in the Amsterdam, Rotterdam and Hamburg offices as well as online by either asking them in the online workplace application Slack or in person if they were willing to participate in an experiment. The criteria to partake in the experiment included: being an employee at DEPT® and proficiency in the English language. The experiment took place between November 7th and December 7th.

Design

The design of the experiment was a between-subject factorial design method with two conditions (VR; VC). The dependent variables were team productivity and communication quality, and the mediating variables were social presence, immersion, and anonymity. The independent variable was the type of technology (VC or VR) applied. The entire experiment took an average of fifteen minutes.

VR Condition

Two Meta Quest 2 headsets were used to conduct the experiment. Both hardware components (headset and controllers) were applied within the trajectory of the study. The Meta Quest 2 headset had a 120 Hz refresh rate and 1832 by 1920 resolution per eye. The 2 Touch Controllers offered inside-out tracking and motion controls. No headphones were used, the audio was from the built-in speakers of the Meta Quest 2 headset. The volume and brightness of the

screens were maintained throughout all participants. Horizon Workrooms, an application offered by Meta, was used to execute this experiment. The platform provides a virtual workspace in the Metaverse and offers the use of collaboration tools (such as a virtual whiteboard) in order to conduct virtual meetings. Accessible through a Meta Quest 2, users are able to collaborate in a VE resembling a physical office and interact with peers as avatars (Meta, 2022a). In Horizon Workrooms, a realistic virtual environment was set up to resemble the DEPT® office spaces. This customization was enabled through the addition of the company logo and adjustment of the layout and room aesthetic. The virtual room was selected from one of the available standard boardroom spaces. The table layout was set to the conversation mode, the room theme to city - sleek. An example of the virtual office space and set-up is depicted in Figure 2 and 3 respectively.

Figure 2: Screenshot of Virtual Environment

Figure 3: Participant in VR condition

VC Condition

The choice of hardware for the VC condition were 2 Macbook Pros (13-inch, 2019, Two Thunderbolt 3 ports). The task was performed using Google Meet as this is the standard applied at DEPT® and thus the software employees are most acquainted with. The VC platform offers audio and video conferencing along with a variety of collaboration tools such as a chat, virtual whiteboard, polls and screen sharing (Google Workspace, n.d.). Participants in the experiment at

hand communicated using both audio and video streams. No headphones were used, the audio from the built-in speakers along with the video from the built-in webcam of the Macbook Pros were used. The volume and brightness of the screens were similar for all participants.

Procedure

After enunciating their willingness to participate in the experiment, participants were randomly allocated to a condition. The researcher shared the instructions prior to the experiment either in person or via Slack. The instructions in their entirety can be found in Appendix C.

If participants were assigned to the VR condition, they were placed in separate conference rooms adhering to the recommended 6.5 x 6.5-foot space by Meta. Participant 1 was requested to take a seat at the spot where the VR headset was placed. Before being instructed to wear the headset, they were debriefed by the researcher on the data regulations, associated risks and instructed to read through the instructions of the case thoroughly. The participant was then able to enter the virtual environment using the VR headset. Upon entering the VE, the participant was instructed to take three minutes to choose and customize an avatar that resembles them and get acquainted with the device and controllers. The researcher informed them when the time was over. Whilst participant 1 was customizing their avatar, the researcher left the room to perform the same instructional procedure with participant 2. They were both instructed to enter the virtual office after their 3 minutes were over. Once the first person had entered the allocated Horizon Workroom Office, they were asked to stay seated and wait until their counterpart appeared to commence with the task. After this was achieved, the researcher left the room for them to perform the task. The researcher re-entered the room after the five minutes were completed, asked the participants to end their brainstorming and whether they had achieved the goal of the study (find a new slogan). They were then asked to remove their headsets and fill out the survey on the Macbook Pro in the room using the online software Qualtrics. In order to respond to the survey and facilitate the data analysis, participants were assigned an individual code to identify which team, member and condition the participant was part of. If the participant successfully submitted their answers, they were thanked and able to leave the room.

If allocated to the VC condition, they were placed in the same conference rooms utilized in the VR condition and asked to take a seat in front of the MacBook Pro. Following the debrief, participant 1 was asked to read through the instructions of the case. Having understood

everything, they were then asked to enter the call on Google Meet and wait for their counterpart to show up. The same procedure was followed for participant 2 in the other conference room. Once this was completed and they were both on the call, the researcher left the room until the time was over. When the five minutes were up and if the task was completed, they were asked to fill out the survey on Qualtrics. As soon as this had been completed, they were thanked and able to leave the room.

Participants that conducted the experiment online followed the same procedures. In the case of the VR condition, participants were required to have a Meta Quest 2 device and install the application Horizon Workrooms. After agreeing on a suitable time slot, participants were sent an invitation to join the virtual room in Horizon Workrooms prior to the experiment. They were encouraged to customize their avatar beforehand. The researcher shared the instructions along with the link to the online survey and individual code via Slack, and instructed participants to read them 5 minutes before the experiment. At the allocated time, both participants and the researcher entered the virtual office environment. Once both participants were present, the researcher informed them of the general information, debriefed them on the study and checked if they understood the task before leaving the room for 5 minutes. Upon re-entering the room, the researcher confirmed the achievement of the task, and instructed participants to take off their headsets and fill out the online survey with their individual codes. The researcher confirmed the completion of the survey and thanked them for their participation with a message on Slack.

For the online VC condition, a 30-minute time slot was arranged for the participant dyads. The invite for the meeting included a link to a Google Meet call, which participants were urged to enter at the allocated time. The researcher shared the instructions along with the link to the online survey and individual code via Slack and instructed participants to read them 5 minutes before the experiment. At the arranged time, both participants and the researcher entered the virtual Google Meet call. Upon the arrival of both individuals, the researcher asked whether they understood the task, provided general information and a short debrief about the study. Thereafter, the researcher left the call for 5 minutes and returned once the time was up. Participants were then asked if they had successfully completed the task and to leave the call to fill out the online survey with their allocated code. The researcher confirmed the completion of the survey and thanked them for their participation with a message on Slack.

Stimulus

Participants performed the same task in both conditions. They were given five minutes to come up with a creative campaign slogan (idea gathering) for a fictitious client case. The context of this task was chosen due to its creative nature, which fits both the company the experiment took place in and which is a common task for virtual teams. McGrath (1984) determined a conceptual framework identifying four typologies: generate, choose, negotiate and execute. As identified by Girotra et al. (2010), the application of idea generation in a work setting is widely applied and is vital to drive innovation within a business. Performance of a positive idea generation task can be characterized as the number of ideas created, the average or variance in quality of ideas and a group's ability to recognize the best idea. This study will apply the use of quality of outcome as a determinant of productivity. The full description of the case can be found in Appendix C.

Study 2 - Measures

Creative Performance

Creative performance was measured by three creative directors at DEPT®, who were instructed to rate the slogans based on how productive they perceived them in terms of quality. The raters were not part of the experimental teams and had no knowledge of the aim of the study. Each answer was rated on a scale from one to ten. The average scores of each slogan from all three experts were computed and applied for both individual members of a dyad for the statistical analysis. To assess the reliability of the raters, the intraclass correlation coefficient (ICC) was calculated. The ICC for scores on the measure was 0.70 (95% CI: 0.50, 0.83). This indicates that there is a moderate degree of consistency in scores on the measure obtained from the three different raters.

Perceived Productivity

Participants were asked to rate their perceived productivity using a five items, 5-point Likert scale ranging from 1 (completely disagree) to 5 (strongly agree). The construct is part of the Individual Work Performance Questionnaire established by Koopmans et al. (2014) and was adapted to fit the context of this study. An example thereof is “We were able to perform the task well with minimal time and effort.” The productivity scale had a good reliability, Cronbach’s α = .78. The entire survey with all items can be found in Appendix D.

Communication Quality

Communication was measured using a four items, 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree), adapted from Burgoon et al. (2002), which assesses the quality of communication within team interactions in the context of the workplace. The questions were adapted to fit into the context of this study. An example of a question is: "We were able to perform the task well with minimal time and effort." The scale demonstrated good reliability, Cronbach's $\alpha = .87$.

Social Presence

Social presence was measured using the scale by Makransky et al. (2017). This scale consists of five items and is rated using a 5-point Likert scale ranging from 1 (completely disagree) to 5 (strongly agree). An example of a question is: "I felt like I was in the presence of another person in the virtual environment." The reliability of the scale was good, Cronbach's $\alpha = .77$.

Immersion

Immersion was assessed according to a 4-item, 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree), adapted from Nichols et al. (2000), for example "During the discussion, I felt like being present in the virtual environment." is an example of a question. The reliability of the scale was good, Cronbach's $\alpha = .87$.

Anonymity

Anonymity was measured using a 5-item, 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree), adapted from Jarvenpaa et al. (1988). The questions assessed the extent to which the participant felt anonymous, for example "I felt anonymous during the task." The scale was found to have an acceptable reliability, Cronbach's $\alpha = .62$.

Control Variables

Age, gender, location, which team participants work in and acquaintance with teammates prior to the experiment were asked. The sample included 42 females (50%), 41 males (49%) as well as 1 non-binary person (1%) and had a mean age of 27.5 years ($SD = 5.3$). Most participants

knew their teammate prior to the experiment (80%). The experiment was predominantly conducted in Amsterdam (39%), closely followed by Online (31%), Rotterdam (25%) and Hamburg (5%).

Data analysis

IBM SPSS Statistics 29 for Windows was utilized to analyze the collected data from Qualtrics. To examine the mediating effect of social presence, immersion and anonymity on the relationship between VR vs. VC and creative performance, perceived productivity and communication quality, a series of multiple regression analyses were conducted using the PROCESS models 4 and 6 (Hayes, 2018). The analysis was based on 5000 bootstrap samples for bootstrap confidence intervals.

Study 2 - Results

In the experiment at hand, the independent variables (predictor) included VC and VR, the dependent variables (outcome) were team productivity and communication. Team productivity was assessed using both sub-constructs creative performance and perceived productivity. The mediating variables assessed were social presence, immersion and anonymity. The general descriptives are portrayed in Table 1.

	Video Conferencing (N = 42)	Virtual Reality (N = 42)
Creative Performance	3.64 (1.35)	4.44 (1.59)
Perceived Productivity	4.40 (0.44)	3.89 (0.75)
Communication	6.11 (0.63)	5.59 (0.82)
Social Presence	3.94 (0.81)	4.25 (0.64)
Immersion	4.77 (1.35)	5.99 (0.75)

Anonymity	5.57 (0.67)	5.69 (0.86)

Table 1: Comparison of means and standard deviations between the mediating and dependent variables

Independent t-tests

To test whether teams in VR were more productive than those in VC, an independent sample t-test was performed. There was no significant skewness or kurtosis in the VC scores (z-score skewness = -1.44 and z-score kurtosis = -0.59) or in the VR scores (z-score skewness = -1.64 and z-score kurtosis = 0.08). Participants in the VC condition (M = 3.64, SD = 1.35) received lower creative performance scores than those in the VR condition (M = 4.44, SD = 1.59). This difference was significant, $Mdif$ = 0.80, $t(82) = 2.50$, p = .01, BCa 95% CI [1.44, 0.16], d = 0.54. Thus, the data confirms H1a, which posits that creative performance would be higher in teams using VR than those using VC. However, participants in the VC condition (M = 4.40, SD = 0.44) reported higher perceived productivity levels than those in the VR condition (M = 3.90, SD = 0.75). This difference was significant, $Mdif$ = -0.51, $t(82) = -3.78$, $p < .001$, BCa 95% CI [-0.24, -0.78], d = 0.82. H1b predicted that participants in VR would report higher levels of perceived productivity than participants in VC; the independent t-test showed no significant support for this hypothesis. Furthermore, communication quality in VC (M = 6.11, SD = 0.63) was also significantly higher than in VR (M = 5.59, SD = 0.82), $Mdif$ = -0.52, $t(82) = -3.25$, p <.01, BCa 95% CI [-0.20, -0.83], d = 0.71, offering no support for H2.

Mediation Analysis

In the first analysis, the PROCESS model 4 (Hayes, 2018) was used to test the mediation effect of social presence, immersion and anonymity in the relationship between VR vs. VC and team productivity and communication quality. VC was coded as 0, VR as 1.

The analysis found a significant effect of condition on social presence (b = .31, p = .056) and immersion (b = 1.22, $p < .001$), confirming H3a and H4a. These findings indicate that participants perceived social presence and immersion to be higher in VR than in VC. No

statistically significant effect of condition on anonymity (b = .12, p > .05) was found, rejecting H5a. Thus, anonymity was not perceived to be higher in either condition.

As demonstrated in the mean comparison analysis, the total effect of condition on creative performance was found to be significant (b = .80, p = .01), confirming H1a. Thus, creative performance was higher in VR than in VC. However, the effects of social presence (b = .22, p > .05, BCa 95% CI [-0.35, 0.78]), immersion (b = .002, p > .05, BCa 95% CI [-0.40, 0.40]) and anonymity (b = .22, p > .05, BCa 95% CI [-0.24, 0.67]) on creative performance were all found to be insignificant. As portrayed in Table 2, the mediating effects of social presence, immersion and anonymity in the relationship between condition and creative performance were also insignificant.

The same step was taken to assess the mediation effect of social presence, immersion and anonymity on perceived productivity. The results indicated that the effect of condition on perceived productivity was significant (b = -.51, p < .001). Replicating the results of the independent t-test, this indicates that perceived productivity was higher in VC than VR. None of the effects of the mediators on perceived productivity showed significant results (b = -.06, p > .05, BCa 95% CI [-0.29, 0.18]; b = .10, p > .05, BCa 95% CI [-.06, 0.27]; b = .09, p > .05, BCa 95% CI [-.10, 0.28] respectively for social presence, immersion and anonymity). No mediating effect of social presence, immersion or anonymity in the relationship between condition and perceived productivity was found (see Table 3 for the indirect effects). Thus, H3b, H4b and H5b were rejected, which predicted a significant positive relationship between the extent to which participants perceived social presence, immersion and anonymity, and team productivity (in neither creative performance nor perceived productivity).

As a last step, the analysis was conducted again with communication quality as the outcome variable to investigate whether one of the mediating variables has a significant effect. The direct effect of condition on communication quality yielded significant results (b = -.52, p < .01), rejecting the notion put forth by H2 that communication quality will be higher in VR than VC. Both social presence and anonymity showed no significant effects on communication quality (b = -.01, p > .05BCa 95% CI [-.28, 0.26]; b = .07, p > .05BCa 95% CI [-.14, 0.29], respectively), showing no support for H3c or H5c. As portrayed in Table 4, the mediating effects of social presence and anonymity in the relationship between condition and communication were not significant. However, immersion resulted in a significant effect on communication quality (b

= .19, p = .04, BCa 95% CI [.005, 0.38]). The mediating effect of immersion on the relationship between condition and communication quality was also significant, see Table 4. Thus, H4c, which predicted a positive relationship between the extent to which teams perceived immersion and communication quality, is supported.

As we supposed that communication would also affect creative performance and perceived productivity, we also conducted a double mediation analysis. Because we only observed a significant mediation between condition and communication via immersion, we limited our examination of the double mediation to immersion. We used the PROCESS model 6 (Hayes, 2018) with immersion as the first mediator and communication quality as the second, and creative performance as the dependent variable. A significant indirect effect between immersion, communication quality and perceived productivity was found (b = .13, BCa 95% CI [0.05, 0.24]). However, no significant indirect effect between immersion, communication quality and creative performance was found (b = .03, BCa 95% CI [-0.08, 0.19]). Thus, the double mediating effect of immersion and communication quality was only significant for perceived productivity.

	Indirect Effects	95% Bootstrap CI BootLLCI	95% Bootstrap CI BootULCI
Social Presence	.067	-.146	.285
Immersion	.003	-.534	.515
Anonymity	.026	-.047	.211

Table 2: Overview of mediating effects of all mediating variables on creative performance

	Indirect Effects	95% Bootstrap CI BootLLCI	95% Bootstrap CI BootULCI
Social Presence	-.018	-.134	.060
Immersion	.127	-.054	.310
Anonymity	.011	-.019	.122

Table 3: Overview of mediating effects of all mediating variables on perceived productivity

	Indirect Effects	95% Bootstrap CI BootLLCI	95% Bootstrap CI BootULCI
Social Presence	-.002	-.112	.096
Immersion	.237	.018	.463
Anonymity	.009	-.026	.161

Table 4: Overview of mediating effects of all mediating variables on communication quality

Discussion

The objective of this study was twofold. On the one hand, it aimed to determine how professionals see the advantages and disadvantages along with the role and future of VR in the workplace. On the other hand, the goal was to investigate whether the difference between teams working in VR and VC influences team productivity levels and communication quality in employees. A mixed-methods approach was applied to find answers to the questions at hand.

Twelve experts were asked for their input using semi-structured interviews and eighty-four employees at DEPT® conducted an idea generation task in one of the two conditions.

The insights from the interviews revealed that, although VR shows promising potential for future collaboration scenarios in the workplace, the current added value for meetings is not substantial enough yet. The expansion and inclusion of improved collaboration tools into the environment are vital for the future implementation of VR in the workplace. Due to the physical and financial barriers, the use of VR in the workplace is limited to niche use cases such as creative collaboration or project kick-offs. Additionally, the pivot from VC to VR would be too big of a shift in how an everyday individual consumes content and would thus be laborious to implement on a wide-scale basis. Several participants touched upon AR as a feasible alternative, as it does not completely replace the whole world but rather still allows users to interact with and see the real world. In addition to social presence and immersion, anonymity was also identified as a key opportunity offered by VR. The construct was thus taken into account as a mediator in the experiment.

We treated team productivity as an overarching term encompassing both creative performance and perceived productivity. H1a posited that creative performance levels would be higher in teams using VR than in teams using VC, and H1b proposed that teams using VR will have higher perceived productivity levels than teams using VC. H1a was confirmed. Creative performance (assessed by three creative directors at DEPT® that were not aware of or part of the experiment) was indeed significantly higher in VR than VC. This indicates that although participants' self-perception of productivity was found to be lower in VR, the creative performance of the outcome was higher. These results strengthen the case for the assumption that various elements of collaborative VR environments can stimulate the quality and creativity of ideas. For one, the immersive nature of the VE can eliminate distractions from the physical world and foster undivided attention to a task (Li et al., 2019; Tenorio-Morales et al., 2020; Ruvimova et al., 2020). VR further offers 3D tools along with avatar-mediated collaboration, which have exhibited the capability to stimulate idea generation in virtual teams (Aufegger & Elliott-Deflo, 2022; Ide et al., 2020)

Contrary to expectations, we found that participants perceived their teams to be more productive in VC than VR, rejecting H1b. The study at hand challenges previous findings by Li et al. (2019) and Tenorio-Morales et al. (2020), as our results suggest the opposite. This discord

could be explained by the novelty of the technology to the participants. As Google Meet (a form of VC) is seen as the standard approach to virtual meetings at DEPT®, the novelty factor may have provided a pretense to the impacted productivity levels in VR. Biener et al. (2022) concluded from their experiment of working in VR for a week that several of the participants' scores in the VR condition significantly improved after a day or two. This indicates that users might need an initial period to get acquainted with the new technology and to be able to make use of the full functionality of tools offered, and provides reasoning as to why this experiment (of 5min) may have led to lower scores. Furthermore, the application applied in this study (Horizon Workrooms) is only accessible in beta (an experimental version used to receive user feedback, which is generally less stable). Some of the features may not have been entirely functional or the app may have had high latency, which could have impaired performance levels. Therefore, the greater familiarity with VC in combination with the novelty of VR and malfunctioning features may have led participants to perceive VR as less productive, however, this perception did not correspond with actual results as measured by the study.

An unexpected outcome of the study was the significantly higher levels of communication quality found in VC compared to VR. H2, predicting that communication quality would be higher in VR than in VC, was not supported by the data as it contradicts the findings of Tenorio-Morales et al. (2020), Wei et al. (2022) and Maloney et al. (2020). One possible reason for this difference may be similar to the finding beforehand on perceived productivity levels that due to the novelty of the technology, communication modalities and processes may have been impacted. At present, it may still feel more natural for participants to communicate in VC than in VR. Additionally, having to focus on generating a creative idea as well as figuring out the functionalities (how to access the internet, draw on a virtual whiteboard or type using the controllers) may have had a bearing on the convergence process. Khojasteh and Won (2021) note that amateur users of VR may take longer to adjust to both the technology as well as AMC, which could lead to difficulty engaging with a teammate and focusing on the task. Lastly, the limitability of Horizon Workrooms and the device of choice applied in this study could account for indifference due to the lack of natural facial expressions through the avatars. As it is still in its early stages, the avatars may not convey natural and enough social cues, which have been shown to account for a rich sense of communication. The experiment was conducted with Meta Quest 2. Toward the end of the study, Meta released a new version of the device (Meta Quest

Pro). Albeit the considerably higher price tag, the device offers a wider range of natural facial features along with eye tracking (Meta, 2022b), which could contribute to better AMC in VR (Wei et al., 2022).

H3a put forward the notion that social presence will be higher in VR than in VC. Corroborating with previous research, social presence was reported to be higher in VR than in VC, confirming H3a and contributing to the validation of previous research by Oh et al. (2018), Bailenson et al. (2006), Hauber et al. (2006) and Kim et al. (2004). The avatar-based interaction and the shared environment indeed seemed to stimulate a sense of presence for the participants.

H3b stated that a positive relationship between the extent to which team members experience social presence and the team productivity levels exists. Further, H3c predicted that the extent to which team members experience social presence positively relates to communication quality. Deviating from prior findings by Oh et al. (2018) and Greenwald et al. (2017), no significant mediation for social presence on both team productivity (on neither creative performance nor perceived productivity) and communication was discovered by our results. In comparison to this study, the experiment conducted by Greenwald et al. (2017) totaled 30 minutes in a VR environment and only consisted of 6 dyads. This small sample size could impair the credibility of their findings. It's worth noting that a large proportion of the participants in the study (80%) were already familiar with each other prior to conducting the experiment, which may have played a role in the findings. The pre-existing relationship among team members may have created an assumption that perceived social presence was already high, leading to the VR condition not having a considerable effect on team productivity and communication quality.

H4a posited that virtual team members in VR will experience a higher degree of immersion than participants in VC, and was confirmed. This study adds to the accumulating body of evidence supporting the assumption that immersion is higher in VR than in VC. Thus, the findings by Slater and Sanchez-Vives (2016), Maloney et al. (2020) and Hsu (2010), who put forth the notion that factors present in VR such as sensory perceptions, gestures, interactivity and avatar embodiment enhance immersion, are confirmed.

H4c was also supported, which predicted a positive relationship between immersion and communication quality in virtual teams. In the presence of VR, high levels of immersion led to higher levels of communication quality within the virtual teams. This corroborates with findings

that AMC offers higher immersive experiences and additionally provides support for the notion posed by the media naturalness theory (Kock, 2014). Tying the results into this theory, we propose that communication in VR offers the ability to communicate in a more natural way than in VC, as one becomes oblivious to the technology and is fully immersed in the virtual world.

H4b anticipated a positive relationship between the extent to which team members experience immersion and team productivity. However, the mediation analysis found no significant effect of immersion as a mediating variable on both creative performance and perceived productivity. This deviates from the findings by Kut'ák et al. (2019), who attributed the feeling of immersion to higher creative performance levels in a brainstorming activity in VR. However, contrary to this study, their findings are based on a qualitative analysis (verbal feedback after the task and unobtrusive observation). The present study applied the use of self-reported measures to assess the levels of immersion and perceived productivity, which may be a reason why our data showed different results. One of the reasons we predicted immersion to have a positive effect on creative performance was attributed to the flow state, in which an individual is fully immersed and can wholly concentrate on a task (Csikszentmihalyi, 2008). Although research in the field of the required time necessary to enter a flow state is scarce, Csikszentmihalyi (2008) asserted that the state typically transpires only after the person has experienced full immersion on a task for an extended period. Seeing as the experiment at hand only lasted 5 minutes, participants may not have been able to enter such a state in such a short period, offering a possible explanation as to why our results differed.

H5a proposed that perceived anonymity levels will be higher in VR than in VC. Contrary to our expectations, we found no support for this hypothesis. Additionally, H5b and H5c anticipated a positive relationship between anonymity and team productivity (creative performance and perceived productivity) and communication. As our data did not show any significant results, both hypotheses were rejected. This construct was added as a result of the findings from study 1 (expert interviews), in which anonymity was found to act as a mediator for productivity and communication and achieve higher levels in VR due to AMC. One possible explanation for our contradictory finding is that 80% of participants knew their teammates prior to the experiment and all participants were employees at DEPT®. Anonymity may only be relevant with strangers. This was found in a qualitative analysis by Maloney et al. (2020), who state that although anonymity was beneficial in VEs, the effect was much stronger for individuals

with introverted tendencies and with strangers. Thus, for further research it may also be necessary to assess individual characteristics (such as level of extraversion). Furthermore, although Le Hénaff et al. (2015) state that anonymity can be beneficial for performance in virtual teams, they also argue that anonymity could stimulate social loafing in teams, which can negatively impact collaboration.

Implications

The findings of this study provide new insights into the relationship between VC and VR in virtual teams and team productivity and communication quality. The results offer a unique angle on the assessed constructs in the workplace as, contrary to many prior studies which assess students, the convenience sample entailed working employees. It was revealed that VC had a significant positive effect on perceived productivity levels and communication quality, whilst VR positively influenced creative performance levels as well as the mediating variables social presence and immersion. Team productivity and communication quality (with the exception of immersion) were not found to be mediated by any of the investigated variables, pointing towards the notion that there may be other existing underlying factors.

Experts from the twelve interviews formed mixed opinions on the role and future of VR in the workplace. Although generally seen as a promising technology with beneficial qualities, several participants echoed doubts about VR replacing current technologies (such as VC) in the near future. The benefits of meeting in VR over VC are not yet entirely understood and existing platforms are still limited in their ability to offer efficient work collaboration tools. Social presence, immersion and anonymity were found to be important underlying factors. Multiple participants stated that augmented reality (AR) has promising outlooks for the future and may surpass VR by providing more effective and user-friendly options. The bottom line is that VR is still too novel, the use cases too niche and the platforms too elementary for it to be implemented on a regular basis in companies. However, should the physical barriers be surpassed, the platforms be drastically improved and the right price point be achieved, effective collaboration of VR in the workplace could live up to its full potential - but this shift is still a couple of years away. As participant 2 of study 1 put it “We need additional stuff upon Zoom, Meet and Teams and there VR will play a role moving forward - but not today.”

These results have implications for the wider scientific community. The present study, as one of the first to analyze team productivity and communication quality in direct comparison between VC and VR, enriched the portfolio of virtual team collaboration and communication research.

The data has also expanded the limited body of research on immersive 3D VR. Despite the potential of immersive 3D VR, research in this field is relatively scarce. This study, however, has offered a novel perspective by focusing on the use of immersive 3D VR in the workplace. It has provided valuable insights and data that can contribute to a deeper understanding of the benefits and challenges of using immersive 3D VR within a work setting.

It was found that VR positively affects creative performance but impairs perceived productivity and communication quality, advancing theoretical knowledge in the field. Thus, VR appears to stimulate creative thinking, even under the circumstance that users themselves opine that it is ineffective for them. This lends credence to the belief that some distinct aspects of VR stimulate creativity. However, this study has revealed that they do not include social presence, immersion or anonymity. For instance, the fictitious environment away from the office and break from a “normal” working day, the creativity of the avatar creation or the gamification nature of VR could be possible lines of reasoning contributing to this finding. Further investigating which aspects may stimulate creative performance would offer an interesting avenue for further research. The investigated mediating factors social presence and immersion have always been seen as important characteristics of VR, but this study shows that in teams where people know each other, these may not be as important. An analysis of whether and to which extent there are alternate underlying factors that predict team productivity and communication quality would deem a promising area for further investigation.

This study should be considered a stepping stone for future research on VC and VR in the workplace. As we utilized commonly accessible hardware (Meta Quest 2 devices and MacBook Pros), we hope that future researchers will be able to replicate our experimental design and expand our findings. Future studies are suggested to include a larger sample size and longer time frame to assess whether longitudinal effects could lead to clearer indications and understanding of the relationship between the two constructs and variables investigated.

For practice, the findings insinuate some guidelines for the implementation of VR. As VR in the workplace has been shown to have a direct and positive effect on creativity, it is

recommended to incorporate the use of HMDs for creative stimulation in virtual teams. Moreover, the data has demonstrated that perceived productivity as well as communication quality seems to be negatively influenced by VR, turning us to suggest the continued use of VC for employees until the technical constraints mentioned above have been adequately resolved.

Limitations

The study is subject to several limitations. Firstly, DEPT® is a multinational company and this study was conducted on a transnational basis - participants were situated between Europe and the Americas. Thus, cultural biases and language differences may have led to communicative and productive challenges. For instance, team 18 consisted of two unfamiliar employees located in Argentina and the Netherlands, which may have caused notable disparities in terms of their communication and task-oriented processes and expectations. Furthermore, the sample size was relatively young (M = 27.5 years). This, along with the fact that DEPT® is a digital agency, could indicate that participants were more familiar with new technologies than the general population. Lastly, 31% of participants conducted the experiment online. The nature of the setting, compared to a controlled environment with the researcher in an office, may have led to lower ecological validity. However, it should also be taken into account that hybrid working policies are ubiquitous within DEPT® teams, so employees are familiar and accustomed to this type of setting. Therefore, the generalizability of this study must be taken with precaution.

Moreover, this study applied the use of self-report measures to assess perceived productivity, communication quality, social presence, immersion and anonymity. As articulated by Podsakoff et al. (2012), this approach is liable to certain biases which may distort the outcomes and show inaccurate relationships between two parameters. For instance, although all participants filled out the survey directly after conducting the experiment, they may still have difficulties recalling the experience correctly (memory bias). Moreover, respondents may have responded in a way that they believe is expected or they perceive are more socially acceptable (response and social desirability bias). This should be taken into account when interpreting the results.

Conclusion

Concluding, the present study contributed to the general knowledge of team productivity and communication quality in virtual teams by offering a comparative analysis of VC and VR in

the workplace. Both qualitative and quantitative data were gathered to assess the research questions at hand, finding partial support for the notion that team productivity is higher in VR and rejecting the belief that communication quality is higher in VR. These findings have implications for both the larger scientific community and companies and pave the way for future research.

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Appendix A - Interview Questionnaire

Research Objectives

- What are the current dynamics and trends for the future of VR?
- What are the (dis)advantages of working with VR, specifically in terms of team productivity and communication?
- Which factors influence team productivity levels and communication within teams working with VR?

Important to note

- To document the information efficiently, the interview will be recorded (upon given consent)
- The data will be used for research purposes only. Participants remain completely anonymous during the data collection and data analysis.
- All the gathered data will be stored confidentially in an encrypted online database under GDPR guidelines, giving participants the right to inspection and removal of the provided data at any point.
- Participation in this study is entirely voluntary, and no valid reason must be given not to participate. Participants have the right to withdraw from the experiment at any time.

Questions

Can you tell me a bit about yourself?

- Who are you?
- How long have you been working at DEPT® / Other company?
- What is your function?

Can you elaborate on your experiences with VR?

- Have you used VR technology before?
- For what purposes? Work/Leisure?
- What work / What leisure?
- What technologies?
- What were your experiences?

- Advantages / Disadvantages

How do you see the future of virtual workplaces?

What potential do you see for VR in the workplace?

- Advantages / Disadvantages
- Future trends of working with VR

What characteristics of VR do you think could help or hinder cooperation in a virtual team?

- What makes VR different from video conferencing? How do these differences help/hinder cooperation?
- For what types of work would VR be best suited? Why?
- Would VR have any benefits over FTF communication? Which ones?
- Do you feel social presence and immersion are important characteristics of VR? Why (not)?
- Are there any other underlying factors that influence productivity and communication?

Appendix B - Participants Study 1

Participant 1: Managing Director and Partner at DEPT®

Participant 2: Global Creative Director at DEPT®

Participant 3: Chief Strategy Officer at a Singaporean NFT Game Play Metaverse Company and Global Web3 Advisor

Participant 4: Former Principal Consultant at BYTE / DEPT®

Participant 5: Co-Founder of BYTE/DEPT®, Global SVP Creative & Content at DEPT®

Participant 6: Global SVP, Technology and Engineering at DEPT®

Participant 7: Head of Web3 at DEPT®

Participant 8: Director Web3 and Partner at DEPT®

Participant 9: Digital Director at a Global Play and Entertainment Company

Participant 10: Innovation Lead at a Global Cloud Computing Company

Participant 11: Principal Product Design Lead UX at DEPT®

Participant 12: Head of Tech Projects at BYTE / DEPT®

Appendix C - Experiment Instructions

Welcome to this study on productivity within teams using videoconferencing (VC) vs. virtual Reality (VR). Thank you for taking the time to be part of this. During the course of the experiment, we will require your undivided attention, so please read through these instructions carefully. If you have any questions about this study, please contact Nafisa Umar on Slack or via nafisa.umar@deptagency.com.

The experiment will either be conducted using video conferencing (Google Meet) or virtual reality (Horizon Workrooms). The researcher will inform you of which mode of technology you will be working with and assign you an individual number you will need to fill out the survey.

Instructions

You have just landed a new client - Oceana, one of the world's biggest coffee manufacturers. They are planning on launching a new coffee flavor that contains twice the average amount of caffeine per capsule and they have asked DEPT® to help introduce it to the market. Yourself and your teammate must now come up with a creative campaign slogan to pitch to the client. You are encouraged to communicate with your partner to come up with a creative solution and are given exactly **5 minutes** to brainstorm and submit a new idea. After the 5 minutes have been completed, you will be asked to answer an online questionnaire on a laptop, in which you will also enter your slogan. Good luck!

Appendix D - Operationalization Scales

Productivity

P_1: We were able to perform the task well with minimal time and effort.
P_2: We kept in mind the results that we had to achieve in the task.
P_3: We managed to plan the task so that it was done on time.
P_4: We knew how to set the right priorities.
P_5: Collaboration with my teammate was productive.

Communication

C_1: The overall quality of the discussion with my teammate was good.
C_2: The outcome of the discussion with my teammate was satisfactory.
C_3: The execution of the discussion with my teammate was competent.
C_4: The development of the discussion with my teammate was careful.

Social Presence

SP_1: I felt like I was in the presence of another person in the virtual environment.
SP_2: I felt that the people in the virtual environment were aware of my presence.
SP_3: The people in the virtual environment appeared to be sentient (conscious and alive) to me.
SP_4: During the simulation there were times where the computer interface seemed to disappear, and I felt like I was working directly with another person.
SP_5: I had a sense that I was interacting with other people in the virtual environment, rather than a computer simulation.

Immersion

I_1: During the discussion, I felt like being present in the virtual environment.
I_2: My senses were completely engaged during the experience.
I_3: During the discussion, I felt I was in the world the system created.
I_4: During the discussion, I had the sense of "being there".

Anonymity

A_1: I felt anonymous during the task.

A_2: During the task I felt free to say what I wanted to.

A_3: During the task I felt free to talk about things.

A_4: During the task I was not inhibited from using certain words.

A_5: During the conversation I felt I could be completely open.

5-Point Likert Scale

1 = Completely disagree

2 = Disagree

3 = Neither disagree nor agree

4 = Agree

5 = Strongly agree

7-Point Likert Scale

1 = Strongly disagree

2 = Disagree

3 = Somewhat disagree

4 = Neither disagree nor agree

5 = Somewhat agree

6 = Agree

7 = Strongly agree