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From Avatars to Allies: Exploring Team Collaboration in the Metaverse

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Abstract

This paper explores the application of virtual reality (VR) technologies in the metaverse for team collaboration, focusing on its advantages over traditional videoconferencing. We examine the opportunities the metaverse offers for virtual teams' collaborative tasks and the factors that enable effective team collaboration. A lab experiment comparing Meta Horizon Workrooms (a VR platform for virtual meeting rooms) with Zoom demonstrated higher immersion, social presence, and collaboration scores for the virtual environment among the participants. Furthermore, we identify that the metaverse offers novel possibilities for virtual interaction and enables greater focus on tasks and team members compared to videoconferencing. We conclude that the metaverse successfully enhances virtual team collaboration, promoting innovative teamwork and knowledge sharing. However, further exploration of this technology, including attention to nonverbal communication and suitable usage scenarios, is suggested. These findings provide organizations with a foundation for considering the implementation of VR collaboration platforms in the metaverse.

Keywords: Metaverse, collaboration, virtual teams, telepresence, immersion.

1. Introduction

Team collaboration has become an integral part of our everyday working lives: Groups of individuals form teams to jointly create value that is beyond their individual capabilities. When team collaboration proves successful, it enhances productivity and profitability and thus contributes to organizational survival (e.g., Boughzala et al., 2012; Cohen & Bailey, 1997). With today's globalization and digitization of work normalizing geographically dispersed collaboration (including phenomena such as digital nomads, home office, and cross-continent teamwork), the importance of equipping teams with tools to enable efficient virtual collaboration becomes ever more important (e.g., Hacker et al., 2019; Raghuram et al., 2019). Virtual teams are composed of individuals who do not share a physical workspace but work on common tasks using online tools (e.g., Jallow et al., 2021; Schweitzer & Duxbury, 2010; Tea et al., 2022). The growing prevalence of virtual teams creates an opportunity for organizations providing information technology (IT) tools for virtual collaboration, in particular videoconferencing systems such as *Microsoft Teams* or *Zoom* that gained immense popularity.

While these tools facilitate collaboration of virtual teams, they often lack features to support nonverbal communication (e.g., eye gaze or one-to-one eye contact), leading to reduced social presence and a lack of immersion in the shared task (e.g., Boughzala et al., 2012; Mueller et al., 2011; Seymour et al., 2018). Baesler and Burgoon (1987) suggest that nonverbal communication significantly impacts the effectiveness of team collaboration. This can potentially affect performance of virtual teams and collaboration dynamics (Schweitzer & Duxbury, 2010; Cohen & Bailey, 1997). To address this challenge, the introduction of virtual reality (VR) has been suggested (Tea et al., 2022; Pazour et al., 2018), fostering a greater sense of immersion and social presence (Guadagno et al., 2007; Moustafa & Steed, 2018; Schultze, 2010).

Presently, the metaverse is being advocated as *the* future collaboration platform, with VR serving as the underlying technology (e.g., Dincelli & Yayla 2022; Marabelli & Newell, 2023). Yet, despite the attention that the metaverse has received recently, there is little research that provides actual empirical evidence on the opportunities and challenges of using the metaverse for collaboration among virtual teams in organizations (e.g., Cheng et al., 2022; Dincelli & Yayla, 2022; Gräf et al., 2023; Marabelli & Newell, 2023; Seymour et al., 2018; Suh, 2023). It remains largely unclear how organizations can make effective use of the metaverse for collaboration and overcome the challenges that conventional videoconferencing systems bear. Without

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a better understanding, harmful misuse of the metaverse could lead to potential disruptions of teamwork that is crucial to organizational success.

To help understand how organizations can enable effective collaboration in the metaverse, our study aims to explore the potential of team collaboration in the metaverse in comparison to conventional videoconferencing systems, and how organizations can make effective use of this potential. We thus ask the following research questions (RQs):

RQ1: What opportunities does the metaverse offer for collaborative tasks of virtual teams?
RQ2: What factors can enable effective team collaboration of virtual teams in the metaverse?

Based on the above-mentioned literature on the metaverse and on team collaboration, we develop a research model and conduct a lab experiment to collect initial empirical evidence. To do so, we employ a collaborative scenario developed by NASA to observe virtual teams using the VR collaboration platform Meta *Horizon Workrooms* (short: *Workrooms*). *Workrooms* offers a collaborative virtual meeting environment that we compare against the videoconferencing application *Zoom*. Based on a mixed-methods approach, we find initial evidence of significantly higher immersion, social presence, and collaboration scores of groups of participants in the metaverse condition compared to the groups in the videoconferencing condition. In addition, we find that the metaverse offers new interaction and collaboration possibilities, allowing for a greater focus on collaborative tasks and team members in contrast to videoconferencing. For practitioners, we demonstrate advantages that arise from working in the metaverse and how the collaboration of virtual teams in the metaverse can be successfully enabled.

2. Theoretical Background

2.1 Metaverse

The term metaverse originated in the 1992 science fiction novel *Snow Crash* (Stephenson, 1992) as a blend of meta (meaning transcendent) and universe. While the metaverse concept has since matured in both popular media and sciences, its definition still constantly evolves. For this study, we define the metaverse as a next-generation Internet based on virtual environments that are represented in VR (e.g., Cheng et al., 2022; Dincelli & Yayla, 2022). Virtual environments are computer-generated simulated 3D spaces that multiple users can simultaneously interact with and within (e.g., Chaturvedi et al., 2011). Virtual environments can either mimic real-world environments or bring to life entirely imaginative worlds (e.g., Chaturvedi et al., 2011; Schmeil et al., 2012). Like websites on the Internet, the combination of multiple virtual environments creates a virtual universe—the metaverse (Lee et al., 2021).

Table 1. Comparison between 3D computer graphics and VR (Dörner et al., 2019).

3D Computer Graphics	VR
Purely visual representation	Multimodal representation (i.e., appealing to several sensory modalities; e.g., simultaneously visual, acoustic and haptic)
Representation not necessarily time critical	Real-time display
Viewer-independent representation (exocentric perspective)	Viewer-dependent representation (egocentric perspective)
Static scene or pre-calculated animation	Real-time interaction and simulation
2D interaction (e.g., mouse, keyboard)	3D interaction (e.g., body, hand, and head gestures)
Non-immersive representation	Immersive representation

Davis et al. (2009) developed a conceptual model for metaverse research[2] based on five interdependent components: (1) the metaverse itself, (2) users (represented by avatars), (3) technology capabilities, (4) user behaviors, and (5) outcomes. According to this framework, the metaverse can be described as a combination of users, technology capabilities, and user behaviors: The metaverse relies on IT that enables the near real-time rendering of virtual environments, as well as the communication, interaction, and collaboration of multiple users within these worlds (Davis et al., 2009). Users within the metaverse are represented by avatars (i.e., virtual representations that mimic their own physical features, those of others, or that are entirely imaginative). These avatars are typically customizable, allowing users to design and personalize their appearance in the metaverse (Lee et al., 2021). One major goal of the metaverse is to fully immerse users in their virtual environment (e.g., Seymour et al., 2018). In this context, *immersion* relates to the user's feeling of being absorbed by their virtual environment, causing a reduced or repressed perception of their physical environment—the user's physical reality is replaced by VR (Schuemie et al., 2001; Witmer & Singer, 1998). For

[2] Davis et al. (2009) define metaverses as immersive virtual environments (or virtual worlds) without the need for VR peripherals (e.g., Second Life). While we follow more recent literature in suggesting that VR plays an essential role in creating the metaverse (e.g., Dincelli & Yayla, 2022), the five components of the conceptual model still provide valuable insights into how users interact with and within virtual environments.

the purpose of immersion, the metaverse relies on special input and output devices (e.g., motion controllers and VR glasses) that promote seamless interaction with and within the virtual environment (e.g., Dincelli & Yayla, 2022). Users typically operate from an egocentric perspective (i.e., the user is part of the virtual environment, and perception occurs in the first-person perspective), and the VR is multimodal and multisensory (i.e., engages multiple senses; Dörner et al., 2019). Table 1 shows a comparison between traditional 3D computer graphics and VR.

2.2 Team Collaboration

Working in a team permeates all aspects of our working lives (e.g., Boughzala et al., 2012). Team collaboration describes the collective effort of two or more agents (i.e., individuals, teams, or entire organizations) pooling their individual resources and expertise to jointly solve problems and accomplish shared goals (e.g., Davis et al., 2009). Throughout the collaboration process, agents communicate with each other to coordinate their respective areas of responsibility (e.g., Cohen & Bailey, 1997). Team collaboration leads to a cohesive structure that leverages the knowledge, skills, and efforts of multiple agents in situations where the capabilities of a single agent fall short of the desired outcome (e.g., Cohen & Bailey, 1997; Hackman, 1987). Promoting team collaboration within organizations is essential for enhancing productivity and profitability, as well as securing long-term organizational survival (Boughzala et al., 2012). For organizations to effectively coordinate collaboration among their employees, they first require metrics to measure the degree of collaboration. To enable this measurement, Hoegl and Gemuenden (2001) developed the teamwork quality construct (TWQ) as a measure of team collaboration based on six dimensions: (1) communication, (2) coordination, (3) balance of member contributions, (4) effort, (5) mutual support, and (6) cohesion—with truly collaborative teams performing well across all dimensions. A low level of TWQ can lead to a lack of process oversight by stakeholders and inadequate handling of project requirements, which in turn may result in project failure (e.g., Meng, 2012). Additionally, low TWQ can widen the gap between individual goals and the overall team goal (e.g., Ren et al., 2008). Dimensions of the TWQ construct have been applied not only to traditional team structures but also to agile teams (e.g., Stettina & Hörz, 2015) and virtual teams (e.g., Maruping et al., 2015).

In virtual teams, team members are dispersed across different regions and/or organizations (i.e., they operate from different workplaces at least some of the time; Gibson & Gibbs, 2006). In this context, *virtuality* does not imply the use of VR technology. Instead, it indicates that team members frequently rely on IT (e.g., email, videoconferencing, cloud-based office applications) to perform collaborative work—that is, usually working together via conventional online collaboration platforms, but possibly also via the metaverse (Schweitzer & Duxbury, 2010).

The reasons why virtual teams gain significance are manifold: Globalization and digitalization have led to the world being more interconnected than ever before. Organizations have subsidiaries and hire new talents from across the globe. While the COVID-19 pandemic has given a tremendous boost to remote work (e.g., Wang et al., 2020; Hacker et al., 2020; Waizenegger et al., 2020), employees now frequently insist on *staying virtual* due to increased flexibility and work-life balance benefits. This emphasizes the necessity for organizations to support work in virtual teams. While the widespread adoption of videoconferencing tools such as *Microsoft Teams* and *Zoom* has played a major role in enabling virtual collaboration, these technologies also lead to new challenges for their users: Videoconferencing tools create some degree of presence (e.g., Hacker et al., 2019), but individuals still tend to form closer relationships and more frequently collaborate with physically proximate peers (e.g., McKenna & Bargh, 2000). Thus, although videoconferencing alleviates the problems associated with geographical distance, it falls short of eliminating the experience of *feeling apart* from one's peers.

2.3 Team Collaboration in the Metaverse

The metaverse builds upon the principles of conventional online collaboration and elevates them to a new level of immersion by leveraging VR technology. As a result, the metaverse is constantly evolving through the introduction of new technological capabilities (e.g., improved VR peripherals such as motion controllers, omnidirectional treadmills, and haptic gloves) and the possibility of social interactions between its users represented by their avatars (e.g., Dincelli & Yayla, 2022; Seymour et al., 2018). Avatars can engage in a wide range of social interactions that open up opportunities for more effective team collaboration compared to traditional online collaboration platforms (e.g., Dincelli & Yayla, 2022). For example, the ability to effortlessly communicate via facial expressions, body language, and gestures (e.g., Argelaguet, 2011), or the ability to create and interact with virtual objects (e.g., Harms, 2019). The metaverse facilitates social interactions by capturing the interactivity of face-to-face communication within shared virtual environments, using multimodal and multisensory VR peripherals. The potential to achieve much higher levels of telepresence and immersion distinguishes the metaverse from current computer-mediated communication methods such as email or videoconferencing (e.g., Moustafa & Steed, 2018; Mütterlein, 2018), thereby fostering a stronger sense of community and togetherness among its users (e.g., Dencelli & Yayla, 2022; Kane, 2017).

Telepresence (also known as presence) describes the user's subjective feeling of being in a distant environment while physically being in another (*being there*). Telepresence is the illusion of being transported to a real, physical location, allowing users to collect experience from afar (e.g., Davis et al., 2009; Nah et al., 2010; Mütterlein, 2018; Schultze, 2010). Social presence extends the notion of telepresence to social contexts, as it relates to the subjective feeling of having access to a distant other (*being with*). Definitions of social presence commonly incorporate the experience of closeness and connectedness in a (computer-mediated) interpersonal setting (e.g., Kim, 2011; Schultze, 2010; Slater et al., 2003). Moustafa and Steed (2018) provide empirical evidence suggesting that users place a high value on social presence when engaging with virtual environments. Lastly, (tele)co-presence is sometimes introduced as the intersection of telepresence and social presence, as it describes the subjective feeling of sharing a distant environment with others (*being there with others*). A critical factor influencing users' feeling of co-presence involves their ability to interact with virtual peers and jointly manipulate virtual objects (e.g., editing documents on a virtual whiteboard; Durlach & Slater, 2000; Schultze; 2010).

When users have a clear perception of their virtual environment and feel mentally and physically engaged in it (i.e., users perceive that they are *interacting with* their virtual environment rather than *merely being there*), they are considered immersed (Davis et al., 2009; Guadagno et al., 2007). Immersion is an essential factor that influences the quality of both single-user VR (e.g., gaming) and team collaboration (e.g., Marabelli & Newell, 2023). Additionally, immersion increases the likelihood of users repeatedly returning to VR (e.g., Goel et al., 2013). Davis et al. (2009) recognize a high level of immersion as a crucial element for collaboration in the metaverse. However, technological limitations have, so far, restricted the immersion of users (Steffen et al., 2019). The metaverse could enhance immersion and social presence among virtual teams (Moustafa & Steed, 2018). This is facilitated using VR glasses that enable users to fully immerse themselves in virtual environments which are rendered in near real-time (Pazour et al., 2018). VR might potentially revolutionize the way individuals interact and communicate with each other (Maloney et al., 2020). Once the VR glasses are put on, users become absorbed within the virtual environment, seemingly disengaging from their physical surroundings. Virtual environments allow users to immerse themselves in shared real-time applications, resulting in a state of cognitive absorption commonly described as *flow* (e.g., Nah et al., 2011; Mueller et al., 2011). Immersion also fosters a greater sense of connection with others, which in turn facilitates social presence (Goel et al., 2013). In collaborative work, immersion plays a critical role in establishing social presence among team members (Barak-Ventura et al., 2020; Slater et al., 2000).

Today's VR-driven metaverse thus involves an unprecedented level of immersion for organizational collaboration, which limits the applicability of existing work. On the one hand, there is a large body of research on organizational collaboration in virtual worlds (e.g., Boughzala et al., 2012; Davis et al., 2009; Schmeil et al., 2012) and more conventional remote work technologies (e.g., Zoom; Wang et al., 2020; Waizenegger et al., 2020), but this work does not focus on immersive VR contexts. On the other hand, there is also a large body of research on VR (e.g., Seymour et all, 2021; Suh & Lee, 2015), but this work typically does not focus on organizational collaboration contexts. Only recently, a handful of studies have indeed focused on organizational collaboration in today's metaverse, but these studies are primarily purely theoretical and strongly call for further investigation (e.g., Dincelli & Yayla, 2022; Marabelli & Newell, 2023), leaving us without much empirical evidence and organizations without clear guidance. To help provide more evidence, we now build the research model that serves as the foundation for our experiment.

We explicitly differentiate between the concepts of immersion and social presence as drivers of team collaboration: If users feel they are interacting with their virtual environment (i.e., they disengage from their physical surroundings), they are mentally and physically *immersed* in it. If this feeling of closeness extends to their social interactions with their peers, then they are socially present. We hypothesize that both immersion and social presence facilitate cohesion, shared understanding, and communication among team members, which in turn improves team collaboration (and ultimately team performance). The presumed relationships between immersion, social presence, and collaboration are the basis for our research model illustrated in Figure 1 and serve as the starting point for the evaluation of our experiment (see Section 3).

Users' feelings of immersion and social presence are heightened by social interactions, which rely on the comprehension and interpretation of social cues from others, also known as *nonverbal communication* (e.g., Appel et al., 2012; Hall et al., 2012). Nonverbal communication encompasses facial expressions, body language, and vocal cues—that is, everything excluding the actual words spoken (e.g., Hall et al., 2019). Virtual communication and collaboration, unlike real communication, must rely on the technical capabilities of the technology being used (e.g., Hacker et al., 2019). That is, social cues in VR must be mediated by avatars. Four modalities of nonverbal communication have been identified in previous research: Facial expressions, gestures, gaze, and spatial behaviors. Nonverbal communication, along with verbal and text-based communication, is a necessary alternative to convey emotions, feelings, and rich information in a natural way. This allows users to feel more connected to others (e.g., Maloney et al., 2020). While technological development has reached the point where existing group dynamics in the real world could be transferred to team interactions in VR (e.g., Moustafa & Steed, 2018), Lee et al. (2021) also see the need to further investigate collaborative work between different avatars. This ties into the limitation of Schouten et al. (2016) and their call to investigate social presence in avatar-based interactions by looking more closely at their nonverbal behaviors.

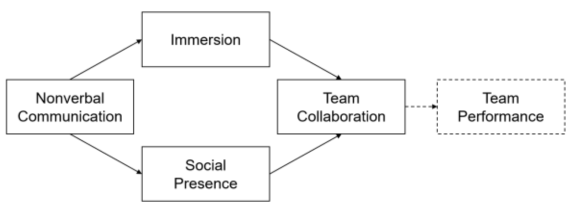

Figure 1. Research model.

3. Experiment and Data Collection

Our study examines the potential of the metaverse for team collaboration in organizational settings. Using a between-subjects design (Kirk, 2009), we assessed user behavior in *Zoom*, a conventional videoconferencing tool, and in *Workrooms*, an emerging VR collaboration platform. This design choice allowed us to compare traditional online and VR-based collaboration experiences directly, addressing both the ubiquity of platforms like *Zoom* and the novelty of VR settings. We selected *Workrooms* as the focus of our study due to its range of features that enhance collaborative efforts among team members: Workrooms provides users with the flexibility to personalize their avatars, select preferred seats at the meeting table, deliver presentations, jot down notes using the integrated whiteboard, and convey emotions through gestures and facial expressions. Additionally, it offers functionalities that enable researchers to easily setup and non-intrusively observe experiments: Researchers have the ability configure the meeting room, live stream each user's first-person perspective via the *Meta Quest-App*, and join the meeting room via a Desktop connection (i.e., appear as a black 2D screen positioned at the rear of the meeting table, aiming to minimize any obstruction to users' interactions; Meta, 2023).

Before conducting our experiment with real subjects, two experts familiar with lab experiments and VR reviewed the experimental setup and the questionnaire. Additionally, a preliminary study with a team of graduate students was carried out to refine the procedure for the actual experiments.

Our subjects comprised a diverse sample of 15 participants between the ages of 20 and 38, eight of them female and seven male. All participants were already acquainted with each other as they were colleagues, which eliminated the need for an initial introduction and the potential disruption of new group dynamics. Furthermore, this scenario mirrors the introduction of VR tools in pre-existing virtual teams in real-world organizations. The 15 participants formed five teams of three members each, with three teams experiencing the VR condition and two teams experiencing the videoconference condition. Both, team and condition assignment were randomized. During the experiment, the teams of both conditions had identical tasks that required team members to collaborate, with the only difference being the operating environment. We adopted a between-subjects design, with each group being exposed to only one condition to avoid carryover effects (e.g., remembering the previous solution).

All participants have experience working with videoconferencing systems and are familiar with the software *Zoom*, so no prior training is required. Participants in the videoconference condition see themselves and the other two team members through the computer's camera. The task is presented to the participants on the Zoom whiteboard. Participants in the VR condition used VR glasses (Oculus Quest 2), which we provided for the experiment in a laboratory. Using the Oculus Quest 2 VR glasses, we chose Workrooms as a virtual meeting environment in which participants interact with each other and collaborate through avatars. Thus, they observe the environment and the other participants visually and acoustically (i.e., "through the eyes and ears" of their own avatar). The VR glasses use external cameras to compute the direction of the participants' gaze and their own gestures (arms and hands/controllers), as well as the movement of their mouths (facial expressions).

Our study participants, being inexperienced in the use of VR glasses and applications, completed a pre-training session to familiarize themselves with the virtual environment. The training included avatar creation, with participants creating their individual digital representations independently. We instructed them to reflect their actual appearance as closely as possible in their avatars. Thereafter, we explained key functions in the virtual conference room represented in *Workrooms* while the participants practiced relevant actions in the virtual environment. This included switching seats at the conference table, using the laser pointer, and moving towards and using the whiteboard with Post-Its and a pen (see Figure 2). After the training, the participants joined their group and we presented the task on the virtual whiteboard to the team, thus creating a consistent starting point compared to the videoconference condition.

Figure 2: Experiment setup as recorded during the experiment.

As a common collaborative task during the experiment, we used a setup originally developed by NASA (2023). For this task, it is important that everyone in the team can participate and contribute throughout the required activities. The task specified that each team would embark on a virtual lunar expedition, landing 15 miles away from their designated camp. The goal was to overcome the challenge of reaching the camp together with a selection among twelve different tools or items at their disposal. Each team had to choose seven items as restricted by their maximum carrying capacity. Their survival depended on team consensus on the utility of each item and subsequent prioritization. While the teams focused on solving this task together, our work primarily examined the nature of collaboration and certain nonverbal communication behaviors in this context.

We collected data from three different types and sources during and immediately after the experiment. First, all teams are recorded while performing the task, so that the actual behavior of the participants could be studied afterwards. In total, we recorded and analyzed 735 minutes (approximately 12 hours) of video across the experiment. We examined nonverbal behavior in more detail and matched them with existing literature, as we presumed that it boosts immersion and social presence and thus contributes to successful collaboration (see Figure 1). We built upon Baesler and Burgoon's (1987) research on nonverbal behaviors and included insights from Maloney et al. (2020) on nonverbal communication in digital settings.

Second, we collected quantitative data with a questionnaire at the end of the task and upon leaving the meeting environment. The questionnaire contained 42 items on 5-point Likert scales. We assessed social presence by adapting the continuously developed Networked Mind Questionnaire (Biocca et al., 2001), also utilized by Schouten et al. (2016). Of 14 items one was "During the discussion, I was aware of my team members". We measured immersion using Kim and Biocca's (1997) questionnaire, which is considered an effective measure for assessing psychological and environmental presence. Of eight items one was "During the discussion, I felt I was in the world the environment created". Hoegl and Gemuenden's (2001) TWQ questionnaire contains 20 items and serves to measure participants' perception of collaboration. One item was "The goals for subtasks within the experiment were accepted by all team members".

Third, a qualitative questionnaire was employed to gather information about participants' general perceptions and emotions concerning either the *Zoom* or *Workrooms* setting. For this purpose, all 15 participants responded to the following four open-ended questions using Microsoft Forms, with their answers ranging from one to five sentences per question:

1. How was your experience? Did you notice anything special regarding the technology, your feelings/behavior, or your colleagues?
2. Imagine conducting the experiment in the other environment (videoconference/VR) - do you expect any differences?
3. What do you think would be possible in the other environment (videoconference/VR) in contrast to your environment?
4. How did you experience your team members' behavior?

4. Results

We employ a mixed-methods approach to analyze both quantitative and qualitative data collected during and after the experiment. This approach includes a quantitative survey, qualitative feedback, and video recordings. In the following, we integrate the findings from these different sources after the completion of the experiment for a holistic analysis, as suggested by Creswell & Clark (2007).

We conducted three independent samples t-tests on our quantitative survey data to test for differences between conditions on the dimensions of our research model: *collaboration*, *immersion*, and *social presence*. These t-tests rely on the assumption of normal data distribution (Fahrmeir et al., 2016). We used the

Kolmogorov-Smirnov test, and with a resulting p-value greater than 2.5%, we concluded that the data followed a normal distribution (Lilliefors, 1967). To ensure equal variances within the data, we performed Levene's test (Guthrie, 2020). With these conditions fulfilled, we analyzed the difference in our model dimensions between the conditions (see Table 2).

Table 2: Independent samples t-test.

Dimension	Zoom	VR	p-value
Collaboration	3.99	4.36	0.127
Immersion	2.40	4.03	< 0.001
Social Presence	3.42	3.90	0.049
Answers ranging from 1 (not agree) to 5 (agree).			

Examining the **collaboration** dimension, we found evidence in our video recordings that participants of the VR condition reported increased motivation and a sense of mutual support as they pursued common goals with their teammates. The participants revealed a pattern of collaborative reflection on outcomes. For example, we observed them regularly turning away from the whiteboard toward their team actively seeking feedback.

In addition, the answers from the qualitative questionnaire support Hoegl and Gemuenden's (2001) elements of collaboration. Based on the feedback from participants in the VR condition, we identified communication, mutual support, commitment, team cohesion, and coordination as consistent positive aspects. In addition, VR collaboration uniquely elicited responses such as fun, excitement, novelty, and enthusiasm. Meanwhile, participants in the videoconference condition primarily affirmed the aspect of engagement. In contrast, they described their collaboration as mundane and lacking in novelty. However, this should be interpreted with caution, considering the participants' familiarity with the *Zoom* environment compared to VR. Also, our results show only slightly different levels of team collaboration with a p-value of 0.127 (see Table 2).

Our quantitative findings further revealed that **immersion** in the VR condition enhanced the ability to focus on the given task, in contrast to participants who engaged through Zoom (see Table 2). The video recordings supported this: the groups in the VR condition demonstrated intense focus on the task and on each other, while those in the *Zoom* group were more likely to be distracted by external stimuli. This includes team members acting in their physical environment and subsequently loosing task and team focus.

In terms of the virtual workspace, participants of the VR condition also considered their avatar representations as legitimate, leading them to become mentally engaged in the virtual environment within minutes. For example, the video recordings show one participant responding to a compliment about his avatar's shoes by looking down, demonstrating his identification with the avatar. Also, more complex actions such as examining their avatars and inspecting features such as their virtual hands contributed to this immersion. In contrast, participants of the videoconference condition reported less immersion and described their experience during the experiment as "just looking at the computer".

During our experiment, participants in the VR condition reported that **social presence** was a highly realistic and natural facet of their interaction. Common real-life group behaviors were effortlessly translated into the VR realm. Evidence of these authentic interactions is visible in our video recordings, corroborating the real group dynamics at play. For example, in Figure 2, a participant on the whiteboard turns to face her colleagues after finishing her presentation, and the group responds to the gesture. A scenario that reflects a real discussion. Figure 3 shows another situation in which a participant leans sideways to get a better view of his peers, indicating both spatial awareness and anticipation of others' movements.

Figure 3: Body obstruction and movement in *Meta Horizon Workrooms*.

In our quantitative analysis, a notable difference in social presence emerged between VR and videoconference conditions (see Table 2). The VR condition reported higher social presence in terms of the attention they felt from and toward their team members.

Finally, participants of the VR condition report that general interactions created a sense of social presence that felt quite realistic. However, this realism is not apparent in **nonverbal communication**. For example, one participant reported making gestures in VR that were similar to real life (e.g., waving hands) but described these actions as "clunky hand movements," indicating a discrepancy between perceived behavior and execution. Reviewing the video recordings corroborated this statement: For example, hand gestures occasionally appeared to be unrealistic or physically impossible as participants held a controller in their hands. Another participant felt less natural engaging with avatars in workspaces compared to face-to-face discussions. Yet another participant found that VR gestures improved communication, though s/he didn't comment on their realism. Emotions and facial expressions were less recognizable in VR than in general interactions. Participants of the VR condition also noted that they would have been able to interpret facial expressions more accurately using *Zoom*.

5. Discussion

We connect the research streams on the metaverse, (virtual) team collaboration, and VR technologies, advancing the limited existing knowledge in this intersection and thereby answering recent calls for research (e.g., Cheng et al., 2022; Dincelli & Yayla, 2022; Gräf et al., 2023; Marabelli & Newell, 2023; Seymour et al., 2018; Suh, 2023). We demonstrate that the metaverse (e.g., via *Workrooms*) can indeed provide effective collaboration platforms for organizations' virtual teams. Our observations show that the metaverse can help stimulate teams to not only develop unique collaboration strategies but also leverage new interactive and social capabilities, leading to increased motivation, engagement, and enjoyment, as well as heightened task focus. The increased immersion and social presence compared to conventional videoconferencing emerged as impactful factors to enable effective collaboration in the metaverse. We underpin these findings with a mixed-methods approach comprising qualitative and quantitative data.

Our study offers several contributions. First, we see initial evidence on team collaboration in the VR-based metaverse, adding an empirical perspective to the largely theoretical discussion of organizational collaboration in today's metaverse (e.g., Cheng et al., 2022; Dincelli & Yayla, 2022). As teams were indeed more effective when collaborating in the metaverse (i.e., *Workrooms*) than via videoconferencing (i.e., *Zoom*), we can essentially confirm the potential of the metaverse for improving virtual team collaboration. We hope that this initial evidence can inspire future studies that focus on further unpacking how this potential translates to and can be established in different real-world organizational contexts.

Second, we also demonstrate the positive impact of increased immersion and social presence that reflect key peculiarities of today's metaverse (e.g., Cheng et al., 2022; Dincelli & Yayla, 2022; Gräf et al., 2023; Marabelli & Newell, 2023) on team task effectiveness, which appear to induce a wider array of actions, fresh team interaction methods, and new information generation opportunities into virtual collaboration. While we have focused on essential main factors, we hope to stimulate the exploration of additional factors that complement the observed effects (e.g., technical design choices, team characteristics) in future studies to expand our current understanding. For example, newer metaverse equipment already offers improved facial expression capture and support for other nonverbal communication. Since such improvements will facilitate nonverbal interaction for collaboration, it remains to see how this may influence observed effects.

Third, our study also provides indications to explain the increased effectiveness of virtual teams in the metaverse, which results from enhanced collective problem comprehension and knowledge sharing. Our results suggest the reduction of team members' mental workload, the introduction of new mechanisms of interaction, and the increased willingness to share information with their peers as drivers behind the resulting beneficial team dynamics. While the team dynamics can be (partly) explained by these insights, we propose to uncover further emerging dynamics. In particular, explaining vicious dynamics that turn collaboration in the metaverse detrimental to task performance may help facilitate an effective use of the metaverse.

Our study does not come without limitations. First, we employed a relatively small sample size, with five groups encompassing 15 participants in total. While our study helps provide initial evidence, greater samples are needed to validate our findings. Second, the participants have similar education, already knew each other before the experiments, and have worked together. While this reflects real-life team scenarios within organizations, it also leaves out collaboration among strangers. Further studies may thus fruitfully complement our findings. Third, while we selected well known tools for our experiments (i.e., *Workrooms* and *Zoom*), we could not completely rule out the possibility of biases induced by their technical peculiarities. Comparing collaboration across different tools may help identify such biases and uncover technical factors to further explain collaboration effectiveness. Fourth, since our study was not longitudinal, participants could not report a habituation effect with *Workrooms*. As the novelty of *Workrooms* may bias participants' behavior during the experiment, our findings would greatly benefit from longitudinal studies focusing on long-term effects.

We hope that the potential indicated for aspects such as enhanced identified communication, mutual support, commitment, team cohesion, coordination, and overall wellbeing in virtual teams, as demonstrated by our study, can help organizations introduce worthwhile use cases and establish the metaverse as a fruitful context for effective virtual collaboration.

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