Whitepaper

Are Virtual Reality meetings effective?
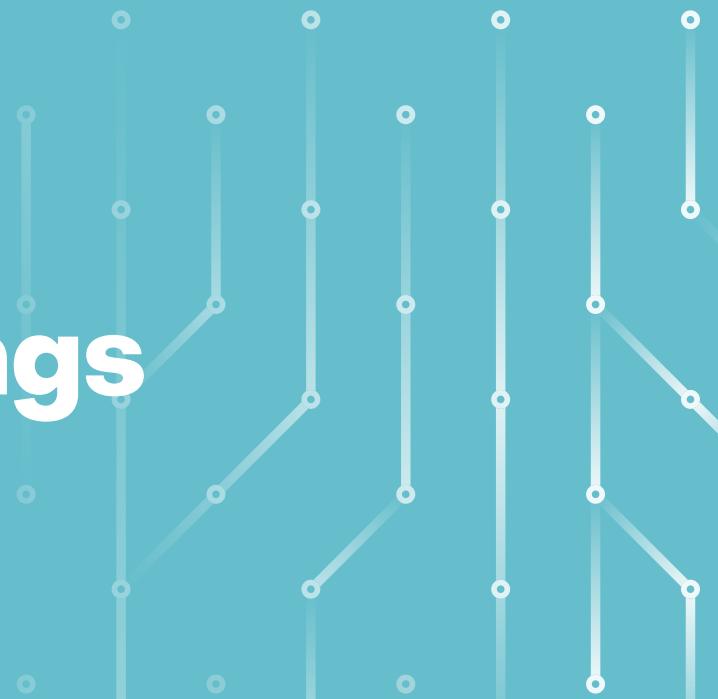
A comparison study of face-to-face, video conferencing and Social XR in the workplace

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TNO innovation for life

Introduction: From necessity to norm

During the Covid pandemic, millions of workers across the globe were forced to find ways to work remotely. Today, video conferencing has become the 'new normal' for collaborative meetings[1], but participant engagement and focus may still be lacking. As eXtended Reality (XR) technologies continue to advance, a key question surfaces: can XR be used to improve meeting efficacy, and yet address some of the pitfalls of regular video conferencing?

Towards the enterprise metaverse
eXtended reality (XR) is a fusion of immersive technologies that blend the physical and virtual worlds. It includes Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) technologies. Social XR is a key enabler for building the metaverse: a network of interconnected virtual worlds in which people experience presence, persistence and immersion. The future of the workplace will be partly shaped by the enterprise metaverse, in which Social XR and other technologies are used for novel forms of communication, collaboration, and interaction.

Remote working offers several advantages. It has a lower carbon footprint, saves commuting time, and fosters healthier work/life balance[2,3].

Most workers report that collaboration is effective in video conferencing settings. But studies also show that a significant number of remote workers experience loneliness and isolation[4]. Those participating in regular, online 2D meetings also report increased fatigue[5], and higher risks of burnout and depression or the absence of important social cues[6].

The rapid advancement of Social XR technologies may reduce distances and offer significant relief for these negative consequences. However, fully developed technology is not enough. That technology must also be accepted by society, and conform to European standards for data protection, privacy, and ethics. In 2023, TNO studied the use of XR technology in the context of business meetings and the enterprise universe. How does it compare to face-to-face (F2F) and video-conferencing (VC) collaborations, and can it enable a new era of more efficient working and collaboration?

1   Chew, Debbie and Mahsa Azizi (2021), "The State of Video Conferencing 2022," Dialpad, (accessed August 15, 2023)
2   Mohamedbhai et al. (2021), "Advent of the virtual multidisciplinary meeting" National Institutes
3   Standaert et al. (2022) "Business Meetings in a Post-Pandemic World: When and How to Meet Virtually?" Business Horizons
4   S. Dijkstra-Soudarissanane, S. Gunkel, V. Reinders, "Virtual Visits: Life-size Immersive Communication" In Proceedings of the 12th ACM Multimedia Systems Conference (MMSys '22). Association for Computing Machinery
5   Fosslien, L., & Duffy, M. W. (2020). "How to combat zoom fatigue". Harvard Business Review, 29, 1-6.
6   Sharan N.N., Toet A., Mioch T., Niamut O., van Erp J.B.F. (2022) The Relative Importance of Social Cues in Immersive Mediated Communication.
     In: Ahram T., Taiar R. (eds) Human Interaction, Emerging Technologies and Future Systems V. IHIET 2021. Lecture Notes in Networks and Systems, vol 319. Springer, Cham.

The research questions

In order to better understand how people experience XR technologies and their use in the workplace, TNO conducted an independent, controlled experiment to uncover answers to several research questions:

- How do people experience work meetings conducted in different settings (F2F, VC, and XR)? What are their technological, collaborative and well-being experiences?
- How are different types of meetings (brainstorms, presentations, structured meetings, negotiations) perceived in the different settings?
- What are the potential effects of using Social XR technologies on a large scale in the workplace?

The TNO advantage
As an independent research organisation, TNO is uniquely qualified to examine questions about Social XR technology and adoption. In addition to our extensive experience in XR technology development, our organisation also has expertise in the social, regulatory, and health aspects that are so essential for full adoption of any technology.

In a unique, multidisciplinary team, TNO designed both a qualitative and quantitative study to determine the role that XR

might play in our future work environment. Participants engaged in negotiations, meetings and task-related assignments in three settings: F2F, VC and XR. By combining both qualitative and quantitative studies, statistically relevant conclusions could be drawn about the experience of XR in the workplace.

The quantitative study consisted of large numbers of controlled, standardised experiments with students. It aimed to measure the quality and efficacy of meetings in XR as compared to the other two settings. In addition to recording the meetings for future study of objective data like the number of words spoken, the flow of conversation, the number of interruptions and the effective completion of the task given, TNO also provided participants with a survey to collect subjective feedback.

The qualitative study aimed to gather more in-depth insight into the experiential aspects of the meetings. It focused on participants' engagement, conversational flow, and system usability.

Participants were professionals who regularly engage in business meetings. The feelings, reactions and performance of participants were carefully monitored and obtained through questionnaires.

Replicable experiments, relevant results

The results of the two studies revealed consistent, correlated, and clear results. Participants in the studies were eager to try the XR technology that is currently far from broadly adopted.

In both the quantitative and qualitative studies, TNO researchers found consistent results in the efficacy of XR meetings, as compared to F2F or VC.

All are equally effective
There was no significant difference in the quality of task performance in the three meeting settings. Participants were able to satisfactorily complete tasks or nego-tiations, whether meeting F2F, in VC or in XR. However, these short experiments did not study the effects of longer use of the technologies.

XR is enjoyable
Participants rated the XR meetings as even more enjoyable than F2F meetings, and significantly more enjoyable than VC meet-ings. XR conversations were perceived as more similar to F2F meetings than to video conferencing meetings.

XR meetings have better flow
With features such as easier turn-taking and constructive interruptions, XR meet-ings had better flow than video confe-rencing. Participants also reported higher concentration levels, as they experienced fewer distractions and a higher level of engagement.

How will we meet in the future?

Meeting in VR is perceived as very enjoyable.
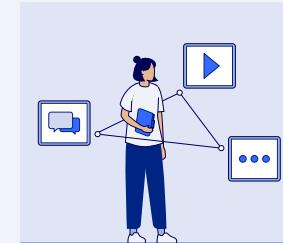
For the young generation, meeting setting does not have a lot of effect on experience.


First indication speech analysis shows that VR conversations are more similar to F2F than Teams.

Social XR Meetings
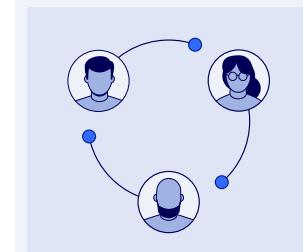
Can have more engage-ment, depending on the user's perspective of the avatars.
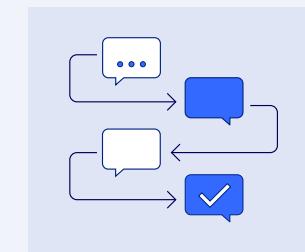
Have a better flow, as a result of easier turn taking and interrupting.

Areas for further development

In recent years, the technology that drives XR experiences has improved significantly. Its application for education, enterprises, health, industry, government, and entertainment purposes is becoming clearer every day. However, in order to make XR a viable and attractive medium for business meetings, more development is needed across several domains.

- **Technology:** Further improvement of XR technology and capacity are needed to accommodate the scope and breadth of wide-scale use. These include advancements in visual quality, digital connectivity, and cloud and edge computing.

- **Cost:** The cost of equipment will need to significantly decrease in order to make it affordable for a broader range of users.

- **Experience:** The current state-of-the-art in XR technology uses cartoon-like avatars. However, study participants note that this is not a professional enough representation of their own digital identity. TNO is currently working on holographic human representation technologies to address this issue, and other organisations are developing their own potential solutions.

- **Interaction:** One of the areas in which F2F or video conferencing meetings were more effective than XR is in the sharing and distribution of relevant documents during a meeting. While F2F and VC allow for easy sharing, there is room for improvement in the way to hand over relevant documents during an XR exchange.

- **Security**: The future of XR, particularly in Europe, will require a targeted and effective structure for data security and privacy, aligned with GDPR and other regulations.

- **Responsibility:** While developing the enterprise metaverse, stakeholders must consider public values including governance, diversity & inclusion, sovereignty, interoperability and sustainability.

Output

The TNO study enabled the production of several tangible outputs, and will continue to do so in the coming year. These include:

- **Scientific Papers:** TNO has submitted two scientific papers for peer review and publication in scientific journals.
  - "Immersive Gathering: insights into virtual workplace meetings"
  - "A comparison of participants' experiences in face-to-face, video and virtual reality negotiation meetings"

- **Dissemination to research and industry networks:** As active participants in local, national and international XR networks, TNO will continue to share the results of the study with network groups, including the European Metaverse Research Network and the EC AR/VR Industry Coalition.

- **Workshops and event presentations:** TNO has already conducted a workshop with various relevant stakeholders and experts to discuss the impact of emerging technological development on work and working conditions. The results of the TNO study supplemented the conversations about working hours, work terms and conditions,

healthy working, and ergonomics, responsibility, privacy and more. TNO will continue to present the study's findings at a variety of conferences and events related to Social XR and/or its application in the workplace.

Conclusion

Will Social XR be part of the future of work? Many signs indicate that it will be. TNO is eager to continue exploring this complex and multi-faceted subject with a variety of partners and stakeholders, with the aim of ultimate benefit to society. In shaping the future of work, the role of XR may be somewhat undefined at the moment, but with each study and discussion, we get closer to finding the answers needed to fully exploit this revolutionary technology.

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