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# Editorial: Use of body and gaze in extended reality

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Editorial on the Research Topic
Use of body and gaze in extended reality

The advent of extended reality (XR) technologies, encompassing virtual reality (VR), augmented reality (AR), and mixed reality (MR), has revolutionized the way we interact with digital environments. These immersive technologies offer unprecedented opportunities for visualizing information, collaborating, and engaging in various activities, from education to entertainment. However, as we delve deeper into the potential of XR, it becomes increasingly clear that understanding the interplay between human perception, movement, and interaction within these environments is crucial. This Research Topic of *Frontiers in Virtual Reality* aims to address these complexities by exploring how body and gaze dynamics influence user experience in XR.

The articles presented in this Research Topic collectively highlight the multifaceted nature of human interaction in XR, focusing on themes such as behavior analysis, tracking methods, individual differences, and the implications of locomotion techniques on user experience. As we navigate through the findings, we uncover insights that not only advance our understanding of XR technologies but also pave the way for future research and applications.

One of the articles, "Rihs et al. Comparison of teleportation and walking in virtual reality in a declarative learning task," investigates the impact of different locomotion techniques on learning outcomes in VR. The study reveals that both teleportation and physical walking can facilitate declarative knowledge acquisition, challenging the assumption that physical movement is inherently superior for learning. This finding underscores the importance of flexibility in design choices for VR applications, suggesting that developers can prioritize user comfort and accessibility without sacrificing educational efficacy.

In another contribution, "Willaert et al. Detection threshold of distorted self-avatar step length during gait and the effects on the sense of embodiment," the authors explore the relationship between avatar movement and user embodiment. By manipulating the step length of a self-avatar, the study identifies a detection threshold for gait asymmetry, revealing that users can tolerate significant discrepancies without losing their sense of embodiment. This research not only enhances our understanding of avatar representation

in VR but also has practical implications for applications in motor training and rehabilitation, where maintaining a sense of self in virtual environments is critical.

The integration of biosensing technologies in XR is further examined in "Pettersson et al. Head-area sensing in virtual reality: future visions for visual perception and cognitive state estimation." This article proposes a visionary approach to personalize virtual content based on users' physiological responses and cognitive states. By leveraging advanced AI algorithms, the authors suggest that future VR systems could adapt in real-time to optimize user experience, enhancing engagement and manipulating cognitive workload. This innovative perspective highlights the potential for XR to become more responsive and user-centered, ultimately leading to more effective training and educational tools.

The exploration of human pointing behavior in XR is addressed in "Schuetz and Fiehler Object center of mass predicts pointing endpoints in virtual reality." This study reveals that the center of mass of 3D objects significantly influences pointing accuracy, providing valuable insights into the sensorimotor processes underlying hand-eye coordination in virtual environments. Understanding these dynamics is essential for designing intuitive interaction methods in XR, particularly in social settings that require precise communication gestures or within the context of medical rehabilitation.

The role of AR interfaces in pedestrian safety is critically examined in "Tabone et al. Immersive insights: evaluating augmented reality interfaces for pedestrians in a CAVE-based experiment." This research demonstrates the effectiveness of various AR interface designs in enhancing pedestrian awareness and decision-making in the presence of automated vehicles. The findings emphasize the importance of interface placement and user attention allocation, suggesting that well-designed AR systems can significantly improve safety outcomes in real-world scenarios. A secondary finding by the authors was a high correlation between the CAVE protocol and an online study, highlighting that intuitiveness ratings may be appropriately measured by less costly and more approachable online experimental designs.

Lastly, "Melendrez-Ruiz et al. An exploratory study combining eye-tracking and virtual reality: Are pulses good "eye-catchers" in virtual supermarket shelves?" investigates consumer behavior in a virtual supermarket setting. By analyzing gaze patterns, the study reveals that pulses (lentils, chickpeas, ...) do not attract significant visual attention compared to other food categories. These insights can inform marketing strategies aimed at increasing pulse consumption, showcasing the potential of XR to influence real-world behaviors through virtual experimentation.

One methodological challenge common to the six papers is replicating real-world conditions in virtual environments. The reliance on non-articulated hand models in the pointing accuracy study may have affected the results, while the CAVE-based experiment faced technical issues that could have influenced participant feedback. Additionally, the varying levels of prior VR experience and video-gaming habits among participants could impact their behaviour, highlighting the need for more comprehensive assessments in future research. One study conducted a power analysis and determined that a minimum of 60 participants was necessary for robust results, while another study recruited 120 participants. In contrast, the three other experimental studies did not perform a power analysis and recruited approximately 30 participants each. We want to emphasize the importance of statistical power in this context. Given the unique challenges associated with VR protocols, more extensive recruitment efforts may be required to ensure valid and reliable findings.

Collectively, these articles contribute to a deeper understanding of how body movement, gaze behavior, and individual differences shape user experiences in XR. They highlight the need for continued research into the ecological validity of XR environments, particularly as we strive to create systems that align with natural human behaviors and preferences. As XR technologies continue to evolve, it is imperative that we prioritize user-centered design principles that account for the complexities of human perception and interaction.

In conclusion, this Research Topic serves as a call to action for researchers, developers, and practitioners in the field of XR. By fostering interdisciplinary collaboration and embracing innovative methodologies, we can unlock the full potential of XR technologies to enhance learning, improve safety, and enrich user experiences. As we move forward, let us remain committed to exploring the intricate dynamics of body and gaze in XR, paving the way for a future where immersive technologies seamlessly integrate into specialized applications, such as advanced training environment, therapeutic practice, social interaction, video gaming, innovative designing process, and human experimentation, ultimately enhancing our capabilities and understanding in these fields.

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