Nonverbal Behaviors and Engagement in a VR Classroom: Examining Associations Between Gaze, Distance, Social Presence, Fatigue, and Learning Outcomes Over Time

Nonverbal behaviors are essential in communication, conveying cues that words alone cannot express (Phutela, 2015). In education, these behaviors help support student engagement (Wulandari et al., 2024). With the emergence of virtual reality (VR), there is new potential to explore these nonverbal behaviors more closely, as the modality allows recreation of physical motions with discrete data tracking. The present paper aims to examine longitudinal correlations between various nonverbal behaviors (e.g., gaze) and self-reported measures (e.g., social presence and virtual meeting fatigue) in a VR classroom. Previous research has examined nonverbal VR behaviors alongside social presence (e.g., Bailenson et al., 2004). The present paper hopes to build upon this by employing a naturalistic approach in which social presence, and other measures such as virtual meeting fatigue, are closely examined within a 15-week long undergraduate-level class, providing a rich amount of movement data to explore.

Literature Review

Social presence—the perceived sense of "being with another" (Biocca et al. 2003)—fosters engagement, enjoyment, and perceived learning in collaborative online learning environments (Cobb 2009). VR provides an opportunity to achieve higher levels of social presence due to key affordances, high interactivity and immersiveness, allowing for virtual environments to mimic the physical features of non-mediated communication (Yassien et al. 2020). Virtual proximity can affect people in perceiving others as proximity does in in-person communication (Chin et al. 2012).

Teacher-student eye contact and interpersonal dynamics can foster a sense of social presence and connection. Haataja and colleagues (2021) found that students tended to sustain eye

contact more when teachers exhibited high levels of communication, indicating warmth and attentiveness, which enhanced social engagement and student motivation. Another study supports this similar claim, that sustained gaze reflects engagement, through an eye-tracking measure (Kaakinen 2021).

Hence, we put forward the research question of how interpersonal distance (RQ1a) and social gaze (RQ2) relates to social presence. Social gaze and interpersonal distance will be viewed separately and not together through the lens of Equilibrium Theory (e.g., Argyle & Dean, 1965) when comparing to student social presence as students report other students as a collective rather than individually. However, instructor social presence has the potential to view the two measures together, given the direction towards one person, so that relationship will be examined as well (RQ3).

Virtual Meeting Fatigue (VMF), often referred to as Zoom fatigue, is characterized as social, emotional, motivational, and visual exhaustion caused by virtual meetings (Fauville et al. 2021). Scholars have suggested potential causes of VMF (Bailenson 2021; Riedl 2022), one of which is related to the limited capability of delivering and comprehending nonverbal cues (Fauville et al. 2023). Studies examining the causes of VMF have primarily focused on videoconferencing environments, where meeting attendees experience limited affordances for producing nonverbal cues due to being confined to a small screen. In contrast, in VR, individuals can move their body parts by embodying avatars. Virtual environments allow people to express nonverbal cues more freely, as embodied avatars represent their body movements—such as approaching by walking, signaling attention through head orientation, pointing to signal greetings and to share attention (McVeigh-Schultz & Isbister 2022). There is potential that VMF

can be mitigated in virtual environments compared to videoconferencing due to these nonverbal behaviors.

Therefore, we also put forward the research question of how movement (RQ4), social gaze (RQ5), and interpersonal distance (RQ6) relates to VMF.

Methods

An online, asynchronous course at a large university was used to examine our proposed research questions. The course met biweekly either on Zoom or in VR via a head-mounted display (Oculus Quest 2). During VR sessions, the course met in EngageVR, a networked platform for professional meetings, which was recorded to track behaviors. An existing R library was used to tidy the raw data format. For analysis, we will only be examining the sessions held in VR. There were 36 students in the course, and each was given extra credit for completing each survey. If students did not consent to participate (which wasn't available to the instructor or teaching assistant), they still had the opportunity to complete the survey for extra credit; that data was used exclusively for course evaluation.

Measures

The survey was administered after each class session, including the measures of instructor social presence, student social presence, VMF, perceived learning, and class enjoyment. These measures were adapted from previous research (see Table 1).

In the class recordings, students' head and hand positions/rotations were recorded each frame. From this data, we wrote a Python script to calculate *student-instructor* and *student-student distance* by taking the coordinates of each person at each frame to find distance, ultimately taking the average distance over the course of a session. *Movement* is calculated by taking the change in coordinates each frame and totalling them together. Social gaze is calculated

in *student-instructor* and *student-student direct gaze* (the number of seconds the student spent looking towards the instructor or another student, respectively) by taking the direction of the student's orientation and direction towards another person (either another student or the instructor) each frame and calculating the dot product. The dot product of unit vectors returns a value between [-1, 1], with 1 being the two directions exactly matching, so a threshold of .75 was chosen to provide a range. If multiple people are within this threshold, the group (student or instructor) closest in distance will be chosen for attribution. This value acts as a proxy for direct gaze, because while research indicates that people turn their entire head to place the object-of-interest within the center of view (Clay et al., 2019), we cannot assume that is proper gaze without eye-tracking for validation. Therefore, we plan to calculate peripheral gaze by also considering the threshold ranges of 0-.74 in another measure.

Analysis

For analysis, we plan to examine the relationships between social gaze, interpersonal distance, and general movement using repeated measures correlations and regressions. General descriptives will also be provided (e.g., in-class group activities relation to these measures). A full analysis of the results will be ready for presentation at the conference, and the computational pipeline will be made available as well.

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Table 1. Survey Measures

Construct & Reference	**Scale** (1=not at all, 2=slightly, 3=moderately, 4=strongly, 5=extremely)
Instructor Social Presence (Cronbach's α = .92) *Adapted from (Biocca et al., 2003; Kang et al., 2007)*	– It felt like we were together – I feel like the instructor was interacting with me – I felt like the instructor was aware of my presence – The presence of the instructor was obvious to me – I felt comfortable communicating with the instructor
Student Social Presence (Cronbach's α = .95) *adapted from (Biocca et al., 2003; Kang et al., 2007)*	– It felt like we were together – I felt like the other students were interacting with me – I felt like other students were aware of my presence – The presence of the other students was obvious to me – I felt comfortable communicating with the other students
Virtual Meeting Fatigue (Cronbach's α = .97) *adapted from (Fauville et al., 2021)*	– I felt tired after today's class – I felt exhausted after today's class – I felt mentally drained after today's class – My vision felt blurry after today's class – My eyes felt irritated after today's class – My eyes hurt after today's class – I felt like avoiding social situations after today's class – I wanted to be alone after today's class – I needed to take some time by myself after today's class – I felt emotionally drained after today's class – I felt irritable after today's class – I felt moody after today's class – I dreaded having to do things after today's class – I felt like doing nothing after today's class – I felt too tired to do other things after today's class
Perceived Learning (Cronbach's α = .90) *adapted from (Rovai et al., 2009)*	– I have changed my attitudes about the course subject matter as a result of today's class – I can intelligently critique the texts used in today's class – I feel more self-reliant as a result of the content learned in today's class – I feel that I am a more sophisticated thinker as a result of today's class

Class Enjoyment (Cronbach's α = .93) *adapted from (McAuley et al., 1989)*	–	I enjoyed today's class
	–	Participating in today's class was fun
	–	I would describe today's class as interesting
	–	While participating in today's class, I thought about how much I enjoy it