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Eye Contact Detectability Thresholds for Mixed Reality Telepresence

Raquel T. Cabrera-Araya, Siyu Huang, Walter Murphy, Anitha Chennamaneni, Voicu Popescu and Edgar Rojas-Muñoz

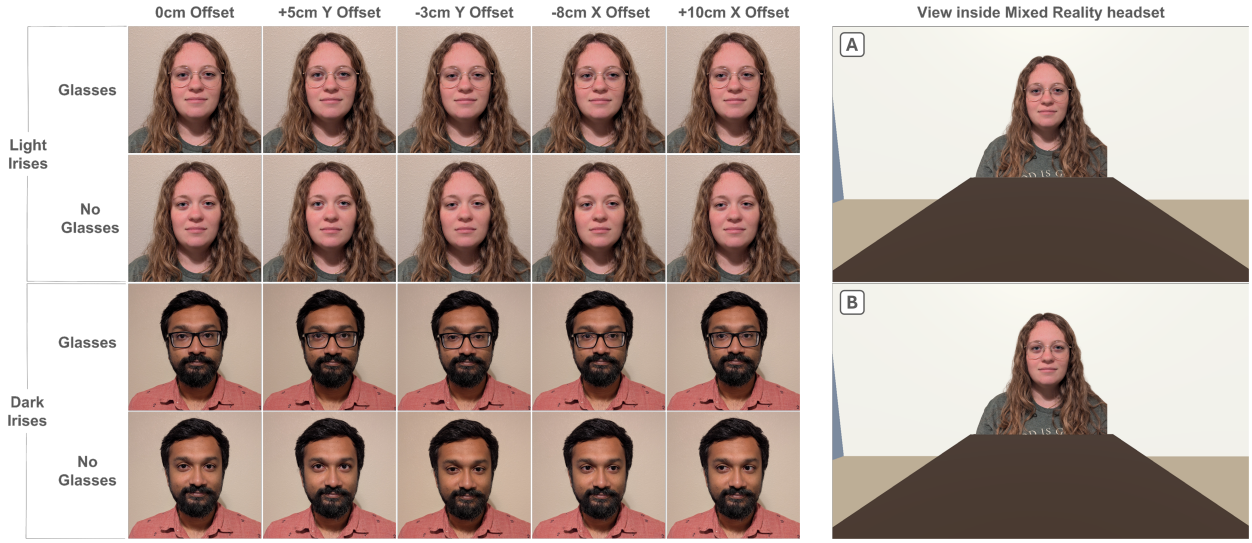


Figure 1: This work calculates the detectability thresholds for perceived eye contact inside Mixed Reality (MR) systems. A user study following a two-alternative forced choice (2AFC) was run in which participants watched pairs of videos of interlocutors inside an MR system. Participants had to indicate which video showed better eye contact: one which had no camera offset (**A**), or another with a camera offset in the [-10 cm, 10 cm] interval (**B**). The videos included interlocutors with and without glasses, with dark and light irises, and different gender.

Abstract— As hybrid telepresence become more pervasive, preserving eye contact between interlocutors becomes paramount for regulating social interactions. Prior work has explored eye contact dynamics in videoconferencing systems, yet eye contact detectability remains under-characterized in mixed reality (MR) telepresence. This work analyses how gaze-direction misalignments disrupt eye contact perception within a 2D-panel-based MR telepresence configuration, which can occur when systems require users to focus on where interlocutors are displayed rather than on the acquisition camera. We calculate eye contact detectability thresholds through a two-alternative forced choice (2AFC) user study (N = 30 per set), analyzing how physical camera offsets along the X and Y axes influence eye contact perception. Participants in an MR environment viewed pairs of videos of interlocutors and indicated which showed better eye contact, one with no camera offset, or another with a camera offset in the [-10 cm, 10 cm] interval. We measured detectability thresholds for interlocutors with and without glasses, with dark and light irises. Findings suggest that detectability varied more systematically with iris color than with glasses, with patterns differing between the horizontal and vertical axes. These insights provide guidelines for understanding eye contact dynamics in MR telepresence. We also report a preliminary exploration on geometric transformations—rotating (yaw) the virtual panel displaying the interlocutor—can compensate for gaze misalignments in MR. Preliminary results suggest that panel rotation may partially restore perceived eye contact for moderate camera-display offsets.

Index Terms—Eye contact, detectability thresholds, mixed reality, telepresence.

1 Introduction

Eye contact is a fundamental component in social interactions, as interlocutors rely on it to establish trust [7], indicate attention and engagement [37], and foster a sense of connection [78]. As remote and hybrid telepresence becomes more widespread, the ability to preserve eye contact between interlocutors becomes of utmost importance. For instance, multiple studies have been conducted around maintaining eye contact in traditional collaboration systems such as teleconferencing [25, 38]. However, less information exists regarding eye contact in Mixed Reality (MR) telepresence systems. The variety of setups these systems can take, e.g., virtual avatars, photogrammetric representations of users, virtual two-dimensional (2D) panels inside three-dimensional (3D) environments, requires the creation of guidelines describing how the interlocutors observe each other within immersive spaces.

This work investigates both how gaze direction misalignments affect perceived eye contact in MR hybrid telepresence, and whether geometric transformations can compensate for these misalignments. Specifically, this work focuses on MR systems that display interlocutors within a 3D virtual space using 2D renders of their webcam feed [27, 55, 75]. Consider a scenario in which two interlocutors (I1 and I2) are having a meeting using an MR telepresence system. I1 is located in a conference room, while I2 is at home using an MR headset. I2 sees a 2D video

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panel of I1. The setup in the conference room includes a screen to display I2 and a camera to acquire the video of I1. This setup introduces a challenge: when I1 looks towards I2's face, displayed in the screen, their gaze direction is not focused into the acquisition camera, leading to a display–acquisition mismatch between actual and perceived gaze direction. As a result, the interlocutor's gaze might exhibit a geometrical offset from the camera that can weaken the remote viewer's perception of eye contact. This in turn can reduce the feeling of presence, coordination, and engagement [1, 79]. It is critical to understand how large the display/acquisition offset can be before the resulting gaze direction misalignment disrupts the eye contact perception for I2. While a 2D-panel-based system might appear visually similar to conventional videoconferencing, the MR environment introduces 3D features that could influence the perception of spatial alignment and mutual attention, such as view selection through head motion, stereoscopic depth cues, and flexible spatial placement. Although we contrast our findings to prior work on eye contact in teleconferencing, the current work focuses on characterizing eye contact detectability thresholds withing this specific MR configuration, and isolating the causal effect of MR relative to a conventional display is beyond the scope of this paper.

We conducted a user study using a Two-Alternative Forced Choice (2AFC) paradigm with 60 total trials, where participants were immersed in an MR environment. Participants watched pairs of video clips, displayed on a virtual panel, showing an interlocutor making eye contact under different camera offset combinations. Participants had to indicate which video showed better eye contact, one which had no camera offset (Fig. 1, **A**), or another with a camera offset in the [-10 cm, 10 cm] interval (Fig. 1, **B**). The videos included multiple male and female interlocutors, with and without glasses, and with dark and light irises. Through this 2AFC setup, perceptual thresholds for eye contact disruption across various real-world variables were obtained while keeping experimental control over visual cues. Furthermore, we conducted a second exploratory study to investigate whether perceived eye contact misalignments can be corrected via geometric transformations. Specifically, we examined whether applying a 3D rotation (yaw) over the 2D virtual panel displaying the interlocutor can restore the perception of eye contact when camera-display offsets are present.

This paper characterizes detectability thresholds for perceived eye contact within MR telepresence systems that display interlocutors via 2D virtual panels, and identifies factors that may modulate these thresholds. The work inspects the following Research Questions (RQ) within MR systems with mismatched display and acquisition points:

- **RQ1**: How does iris color affect the perception of eye contact?
- **RQ2**: How does eyewear affect the perception of eye contact?
- **RQ3**: Are there perceptual differences in eye contact detectability between horizontal and vertical misalignments?
- **RQ4**: Can a geometric transformation of 2D virtual display surfaces compensate for perceived gaze misalignment in MR?

2 Prior Work

2.1 The Importance of Eye Contact

Eye contact is a critical component of non-verbal communication [36, 67]. It serves multiple communicative functions, including conveying attention, emotional states, and engagement between interlocutors [78]. It also plays a key role in establishing interpersonal connection, allowing individuals to coordinate their behaviors and interpret intentions without relying solely on verbal content [31]. Sustained and well-timed eye contact is associated with greater feelings of intimacy, trustworthiness, and empathy, reinforcing the perception of mutual understanding between interlocutors [46,56]. Contrarily, the absence or disruption of eye contact often results in communication breakdowns, reduced rapport, and diminished perceptions of presence [60].

Due to its importance during social exchanges, various methods have been developed to measure and quantify eye contact. Direct behavioral coding, where trained observers manually annotate periods of mutual gaze or averted gaze during conversations, is commonly used to quantify eye contact [37]. Advances in technology have introduced more precise methods, such as mobile eye trackers [50] and head-mounted devices [3], which can measure gaze direction, fixation duration, and synchrony between participants with high temporal accuracy. Furthermore, multimodal sensing systems that integrate gaze with additional signals—such as facial orientation, physiological measures, and audio cues—have gained traction to obtain a more holistic view of eye contact behaviors [61]. These approaches have created a foundation for understanding how eye contact emerges and regulates communication.

Gaze direction is inferred, in part, from the relative position and contrast between the pupil, iris, sclera, and eyelids [82, 83]. As such, it is important to explore how the visibility of eye-regions impacts the judgments of eye contact in MR teleconference systems. In particular, our work focuses on the effects of iris color and eyewear. It has been documented that iris color may influence gaze perception [20], as it changes the contrast between the pupil, the iris boundary, and the surrounding sclera. Furthermore, interactions between sclera and iris color, i.e., dark and light irises, can lead to differences in perceived gaze direction [76]. Eyewear can likewise alter the visibility of eye-region cues. Studies have shown that reducing access to gaze cues, for example through sunglasses or occluding lenses, can change perceived eye contact and related social responses [35,49]. This can also influence mutual gaze, trustworthiness, and social acceptability [54].

2.2 Eye Contact in Telepresence Systems

Remote and hybrid telepresence systems have introduced novel challenges to how eye contact is sustained and measured. These systems aim to bridge the spatial divide by enabling remote users to interact in a digitally co-located space, creating the illusion of physical co-presence [80], and are particularly valuable when physical presence is costly, impractical, or impossible. Examples include videoconferencing platforms [85], room-based teleconferencing [41], telepresence robots [72], and various types of MR-based approaches [18].

Albeit effective, these systems can face difficulties in recreating the same level of co-presence from face-to-face interactions [38]. These challenges can be attributed to the inherit complexity of social dynamics [26], but also to how telepresence systems are designed [39, 66]. In conventional videoconferencing, for instance, the camera is often positioned above or to the side of the screen, which can cause a mismatch between actual and perceived gaze direction. This mismatch disrupts the natural flow of the conversations and can hinder the feelings of presence, engagement, and trust [9]. Furthermore, these systems often segment visual attention across multiple windows—such as chat, shared documents, or participant grids—making it difficult to isolate when and how eye contact is directed toward specific interlocutors [24].

It is therefore critical to create solutions to quantify and restore eye contact when affected by the use of telepresence systems. Early attempts in traditional 2D videoconferencing aligned the viewing direction with the displayed face image via optical devices like half mirrors and beamsplitters [53]. Albeit effective, these setups were often large, costly, and not widely accessible for most videoconferencing users. Geometric transformations have also been explored as simple yet effective solutions to rectify eye position during videoconferencing [81]. Machine learning and computer vision techniques have also led to novel approaches preserve eye contact. For instance, systems have incorporated external cameras around monitors to interpolate between video feeds and obtain a gaze-corrected view [15], warping-based convolutional neural networks have been used to relocate pixels around the eye regions [32], and moving cameras positioned directly behind semi-transparent screens to provide perspective-correct views [66].

More recent approaches have explored neural synthesis as a way to modify the apparent viewpoint or head pose of a remote interlocutor, such as one-shot free-view neural talking-head synthesis [73] and free-view neural 3D head synthesis [57]. While these approaches are effective for improving gaze and viewpoint alignment in remote communication, they can be computationally expensive and undeployable on off-the-shelf, portable MR devices. In contrast, our exploratory correction study investigates a lightweight geometric transformation of

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the virtual display surface, which bypasses the computational cost of neural head synthesis, identity reconstruction, or specialized capture pipelines.

2.3 Eye Contact in Mixed Reality Telepresence Systems

Further exploration is required to confirm if the eye contact dynamics in videoconferencing systems remain applicable for MR telepresence systems. These platforms enhance immersion and realism by supporting spatial alignment, body presence, and even volumetric reconstructions of participants and their environments [68, 74]. These affordances support the transfer of collaboration cues such as gaze direction, hand gestures, and other proxemic indicators [36,62]. A variety of MR telepresence approaches exist, such as sharing virtual replicas of elements in their environments [69], avatars representing surgeons can indicate instructions during medical procedures [23], and 360° videos and 3D reconstructions can be shared to increase situation awareness [67].

Understanding how to remotely transfer eye contact in MR telepresence systems is critical to increase the systems' usefulness and performance, and to foster trust and engagement between interlocutors [79]. Rendering eye gaze inaccurately or introducing latency may cause interlocutors to perceive their peers as inattentive or disinterested, which affects social presence [1]. This was observed in [2]: although the telepresence system effectively communicated non-verbal behavior, e.g. head nodding, participants reported that the virtual characters behaviors often felt mechanical and disconnected from the conversational context. Nonetheless, achieving naturalistic eye contact in MR telepresence is particularly complex. Technical challenges such as facial occlusions due to wearing a head-mounted display, imperfect eye tracking accuracy, and mismatched or offset camera-eye alignment contribute to discrepancies in perceived gaze direction [4]. These mismatches distort users' interpretations of attentional focus and responsiveness, which are essential for sustaining collaboration and rapport [16].

Various methods have been designed to alleviate these issues and support eye contact in MR telepresence systems, such as augmenting gaze cues by rendering them as 3D laser pointers [28], synthetic gaze methods in avatar-mediated interactions [59], and volumetric capture systems that preserve gaze cues [68]. Nonetheless, no perfect solution to achieve eye contact in MR exists yet, and additional studies are required to confirm whether the eye contact findings on conventional videoconferencing remain applicable for MR telepresence. Our work tackles this gap by analyzing the eye contact detectability thresholds when participants are rendered in 2D panels inside MR environments.

2.4 Eye Contact Detectability Thresholds in MR

Prior work in psychology and videoconferencing has established that even minor angular deviations in gaze direction, even 1–5° of visual angle, can lead to a loss in perceived mutual gaze [11, 71]. Quantifying detectability thresholds—the minimum gaze alignment required for two individuals to perceive that mutual eye contact is occurring—is a common approach to achieve and analyze co-presence [11, 45, 47]. These thresholds have proven fundamental in designing telepresence systems [37, 63]. A common approach to compute these thresholds involves showing videos and asking interlocutors to choose which ones exhibited better eye contact [17, 45]. These approaches typically follow a two-alternative forced choice design (2AFC [19], §3.2) to obtain the interlocutor responses, which are then fitted to a psychometric function to compare how eye contact was perceived.

Albeit MR telepresence systems often rely on gaze input for basic functions such as target selection [43], context-sharing [5], or intent-prediction [13], perceptual studies of eye contact fidelity in MR are not as common as in other areas of Human-Computer Interaction (HCI). As such, their applicability to immersive MR contexts remains largely unevaluated. Furthermore, MR's inherit 3D affordances introduce differences that impact the perceived eye contact, e.g., viewpoint-dependent occlusion, varying focal depths, and spatial misalignment between the tracked gaze and rendered eyes [22, 42, 58]. These affordances motivate measuring detectability within MR rather than assuming direct transferability of results from teleconferencing research. Our work therefore uses 2AFC methodology, the gold standard for quantifying detectability thresholds, in order to measure the impact of display-camera mismatches in MR telepresence configurations. The videoconferencing results from prior work are used only to compare and contrast against our findings.

3 Methods

This study was designed as an exploratory psychophysical investigation of eye contact detectability in MR telepresence. We adopted a 2AFC paradigm to estimate detectability thresholds for perceived eye contact. We analyzed how physical camera offsets, in the [-10 cm, 10 cm] interval, along both the horizontal and vertical axes influence the perception of eye contact. Participants inside a 3D MR environment were shown pairs of 2D videos of interlocutors, and had to indicate which video showed better eye contact. This methodology allowed us to quantify perceptual sensitivity to gaze misalignment while minimizing subjective bias. Importantly, the study is not intended to isolate all causal contributors to eye contact perception, but rather *to establish perceptual trends and bounds that can inform MR telepresence system design and motivate future investigations.*

3.1 Panel-based MR Telepresence

Our work utilizes a configuration with 2D video panels embedded in 3D spaces, viewed through an MR headset. This configuration is frequently used as it simplifies acquisition and rendering, while providing representational fidelity. In this context, eye contact errors can occur when the acquisition camera of the interlocutor and the displayed face they are looking at are not spatially aligned. The viewer may therefore perceive the interlocutor as looking away, even when the interlocutor is looking toward the displayed remote user.

Our study does not attempt to isolate MR-specific effects relative to conventional videoconferencing. Instead, it quantifies eye contact detectability thresholds within this MR configuration and identifies factors that may modulate them. We investigate physical camera-display offsets along the horizontal and vertical axes, as well as interlocutor visual characteristics that may influence eye-region visibility, namely iris color and the presence of glasses. Panel placement, viewing distance, head pose, camera height, facial perspective, and lighting are held fixed or left outside the study scope. These choices define the investigated subspace and the limits of generalization. Furthermore, although our study uses clear prescription glasses rather than tinted or opaque eyewear, prescription lenses and frames can still introduce reflections, boundaries, and partial occlusions around the eye region. We therefore include glasses as an ecologically relevant visual factor, while leaving an investigation of the influence of eyewear type and lens reflectivity as future work.

3.2 Two-Alternative Forced Choice Design

The 2AFC method was proposed by Fechner for quantitative perception studies in the Psychophysics field [19]. The method analyzes the relationship between stimuli and responses, and is widely used for threshold detection studies. During the procedure, two versions of the same stimulus are presented **one after the other**; after each trial, the observer has to choose which one they perceived as having a higher value on a specific dimension [6, 77]. Afterwards, psychometric function plots, e.g., a sigmoidal curve [8], are used to depict the proportion of correct responses as a function of the stimulus difference; the function indicates the increase or decrease in the probability of a correct response based on the observers response rates. In a traditional 2AFC, the detection threshold is measured as the offset for which the average correct response rate is 75%, i.e., halfway between chance (50%) and perfect (100%) discernment of the stimuli. Psychometric-function fitting is the standard analysis for estimating detectability thresholds in 2AFC; the recovered thresholds have intrinsic value and provide the basis for our findings. Furthermore, we use the standard sigmoid psychometric fit for threshold estimation as it provides interpretable detectability thresholds. While other fit functions can be used, e.g., polynomial fitting, the sigmoid psychometric fit prevents noisy intersection thresholds that may extrapolate beyond the tested range.

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3.3 Acquiring the Stimuli

Eye contact misalignments were artificially generated by recording four different interlocutors—two female (I1 and I2, **Set A**), two male (I3 and I4, **Set B**)—as they fixed their gaze over various controlled locations. Each set included an interlocutor with light irises and one with dark irises. Figure 2 A-B showcases the setup used to record the videos. A Canon EOS Rebel T7i camera was used to acquire the videos of the interlocutors [10]. The camera used a 35 mm lens and was placed at 165*cm* from the interlocutor, with a height of 120 cm from the floor (Fig. 2, A). Camera distance was selected to approximate typical interpersonal distances observed in seated conversational scenarios, which commonly fall within the lower range of social distance described in proxemics literature [29, 51]. The height of the camera placement approximated the seated eye level of the interlocutors. A cardboard panel with a hole of the size of the lens of the camera in the middle was used to determine the gaze fixation locations. A coordinate frame was defined using the center of this hole as its origin (assuming the radius of the camera lens was negligible). Vertical and horizontal marks were drawn on the cardboard, 1 cm apart from each other, in the range of [-10, 10]. This created a total of 40 marks on the cardboard (Fig. 2, B), representing 40 distinct camera offsets (inspecting **RQ3**). The offset change was selected to span values both below and well beyond previously reported gaze misalignment tolerances for perceived eye contact in videoconferencing systems, ensuring that detectability thresholds could be observed within the tested range [11].

To explore how visual characteristics influence the perception of eye contact, each fixation point was acquired while varying two primary factors in the interlocutors: iris color (dark vs. light; inspecting **RQ1**), and presence of glasses (present vs. absent; inspecting **RQ2**). This led to four different permutations: Dark irises with glasses (A1, B1), Dark irises without glasses (A2, B2), Light irises with glasses (A3, B3), and Light irises without glasses (A4, B4). We improve the generalizability of our threshold estimates by examining factors typically explored in eye contact estimation literature; the novelty of our work stems from the trends uncovered, and not from the factors themselves. Afterwards, each interlocutor was recorded while fixing their gaze at each of the 40 different marks, as well as while keeping their gaze fixed at the center of the camera lens (41 videos). Each interlocutor recorded these 41 videos twice, with and without glasses, for a total 82 videos per interlocutor. This resulted in 328 5-second long distinct videos. Recording parameters, i.e., room lighting, interlocutor head rotation, and video background; camera placement, fixation procedure, and stimulus durations were kept constant across sets. The pre-recorded videos provide replicability and precise control of the stimuli across participants, as live interactions could introduced variability, e.g., spontaneous facial expressions, sneezing, coughing, that could confound the perception of eye contact. Furthermore, we did not use open datasets for gaze estimation, such as MPIIFaceGaze [84] and the Labeled Pupils in the Wild dataset [70] because these primarily provide egocentric perspectives, cropped eye region, or naturalistic gaze markers. Such resources are valuable for training machine learning models, but lack full-face, systematically offset gaze recordings.

Table 1 provides descriptive information of the interlocutors. Facial descriptors were extracted using Dynaface, an open-source Python library that extracts facial symmetry and landmark data from images and videos [30]. These factors are reported to facilitate reproducibility of our work and are not treated as experimental variables. All interlocutors had normal or corrected-to-normal vision and wore their respective prescription lenses when required.

3.4 MR Virtual Space

The videos were observed in a virtual panel inside an MR telepresence application designed for the Meta Quest 3 [52]. The room was comprised of four walls, a table, and an anchored panel in the space to display the videos (see Fig. 1). To ensure that no perception artifacts were introduced when visualizing the videos in the headset, the virtual room was designed to replicate the dimensions of the room in which the videos were recorded (Fig. 2, C). In other words, the perspective of the user wearing the MR headset matched the position of the camera

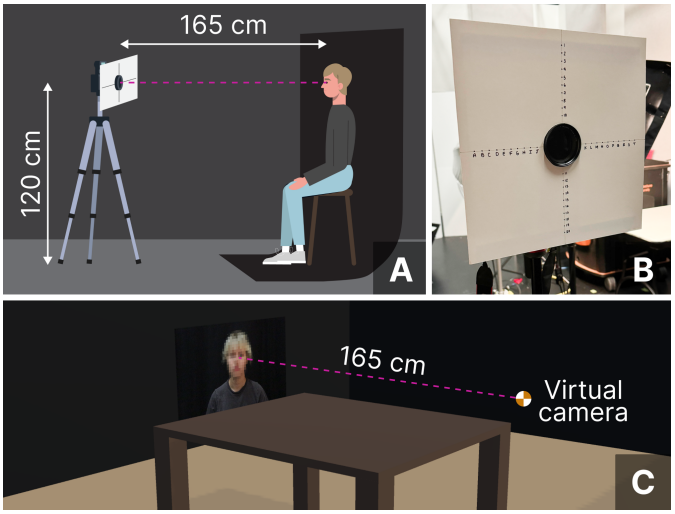


Figure 2: Setup to record the gaze misalignment videos. A) Illustration of the physical setup. B) Cardboard cutout with marked fixation points. C) Virtual space where videos were displayed.

that was used to record the videos, and the distance between the virtual panel and the virtual camera matched the distance between the interlocutors and the real-life acquisition camera. To account for differences in height of the participants, they were encouraged to perform a manual calibration that adjusted the Y-axis position of the virtual panel. The objective of this calibration was to remove vertical offsets that could introduce biases in their perception of eye contact by leveling the eye of the interlocutors, a proxy for making them the same height.

4 Eye Contact Detectability Thresholds

We conducted an IRB-approved user study to define eye contact detectability thresholds in 2D-panel-based MR telepresence systems.

4.1 Experimental Setup

Stimulus Sets A and B were evaluated in separate experimental sessions using the same task and procedure. Participants arrived where the experiment took place and first completed a Demographics questionnaire. Each participant evaluated 41 pairs of videos for eight different stimuli variations (A1 to A4, B1 to B4). Videos were presented sequentially (one after the other) in random order, following the 2AFC design standard practices. For each pair, participants had to indicate which video showed better eye contact, one which had no camera offset ("perfect eye contact"), or another with a camera offset in the [-10 cm, 10 cm] interval. This was done by answering *"In which of the videos did you feel that the person was looking at you?"*. The order within each pair, the offsets within each combination, and combinations A1–A4 and B1–B4 were counterbalanced to prevent randomization biases. Participants took breaks between combinations to minimize fatigue and eye strain.

For each participant, we collected their demographic data and whether they correctly identified the video with no eye contact offsets (binary coded). After completing all combinations, participants were asked to explain of the strategy they used to determine which videos were showing a better perception of eye contact, if any.

Participants: We conducted an apriori power analysis to determine the required sample size. Following Cohen's guidelines for effect sizes [12], we aimed for an effect size of $d = 0.8$ with a statistical power of 0.85 and a two-tailed $\alpha = 0.05$. According to Cohen's power tables, a minimum of 29 participants per set was required to achieve these parameters.

Data analysis: Three steps were performed to analyze the data. First, the correct answer rate for each offset was found by dividing the number of participants who answered correctly for a given offset by the total number of participants. Next, we fit a sigmoid psychometric function separately to the left and right offset data for each combination,

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	Interloc.	Gender	Age	Eye color	Skin color (HSB)	FAI*	Eye ratio	Intercanthal dist.	Mouth length	Outer eye corners	Nostril dist.
Set A	I1	F	23	Dark brown	22,56,65	1.00mm	1.00mm	49.31mm	79.56mm	134.64mm	49.31mm
	I2	F	22	Light blue	18,33,66	4.07mm	0.99mm	56.70mm	74.59mm	158.29mm	53.85mm
Set B	I3	M	34	Dark brown	22,39,56	2.07mm	0.89mm	52.67mm	75.90mm	148.11mm	66.84mm
	I4	M	29	Light hazel	29,38,92	2.02mm	0.92mm	56.11mm	87.00mm	157.74mm	75.83mm

Table 1: Demographic characteristics and facial measurements of the four interlocutors included in Stimulus Sets A and B. Reported values include eye and skin color, facial asymmetry index (FAI) [48], eye ratio, intercanthal distance, mouth length, distance between outer eye corners, and total nostril distance. All distances are expressed in millimeters.

using least-squares optimization. This function, which is standard in 2AFC tasks, is defined in Equation (1).

$$S(d,\alpha,\beta,\gamma,\lambda) = 0.5 + (0.5-\lambda)\left(\frac{1}{1+e^{\gamma\frac{d-\alpha}{\beta}}}\right) \quad (1)$$

d represents the offset, and the parameters α, β, γ, and λ are estimated through the fitting process. We use γ to distinguish the directionality of the curve: left-side and downwards offsets are defined as negative (from 0 cm to -10 cm), and right-side and upwards as positive (from 0 cm to 10 cm). As a result, the left-side sigmoid decreases from left to center ($\gamma = 1$), while the right-side sigmoid increases from center to right ($\gamma = -1$). The remaining parameters serve to fine-tune the curve: α adjusts the horizontal shift, β sets the slope, and γ limits the upper asymptote. Finally, we estimated detection thresholds by identifying the Point-of-Intersection (PoI) of each fitted sigmoid with the 75% correct response line. This yielded one threshold for leftward offsets and one for rightward offsets.

As a supporting inferential analysis, we also fitted a binomial Generalized Linear Mixed Model (GLMM) with a logit link to the trial-level 2AFC responses. This tests if the detectability differences from the psychometric curves are supported beyond visual inspection. The model predicted whether participants correctly selected the zero-offset stimulus based on the levels of the fixed effects. A random intercept for participant–set session accounted for repeated trials. Zero-offset trials were excluded (no meaningful correct response), leaving 9,600 trials and 60 participant-session identifiers in the model.

5 Results

Demographics: The study enrolled 51 unique participants in total (30 male, 20 female, 1 prefer not to disclose): 9 participants evaluated both sets, 21 only Set A, and 21 only Set B, totaling 30 evaluations per set. The demographics questionnaire showed that more than 75% of participants had used a MR headset before (never = 12, once = 12, several times = 21, once a week = 1, multiple times a week = 5); almost 100% had joined meetings using videoconferencing (never = 2, once = 0, several times = 20, once a week = 7, multiple times a week = 22); and more than 85% felt comfortable engaging in eye contact with other people (strongly disagree = 1, disagree = 0, neither agree nor disagree = 4, agree = 29, strongly agree = 17).

The experimental data and their associated sigmoid fitted functions are shown in Fig. 5, which presents the detectability thresholds aggregated across both stimulus sets and grouped by iris color and presence of glasses. Table 2 summarizes the parameters obtained from the least-squares optimization. The third column shows threshold values both in centimeters and degrees. The centimeter values correspond to the displacements on the cardboard panel (see Fig. 2, B), while the angular values were obtained by applying $\theta = \tan^{-1}\left(\frac{\Delta}{D}\right)$, where Δ is the offset in cm and $D = 165$ cm is the fixed distance between the camera and the interlocutor. The full set of fitted psychometric curves for the individual stimulus sets are provided in Appendices A and B, as well as the sigmoid parameters for each independent set in Appendix C (see supplemental material accompanying our paper).

5.1 Generalized Linear Mixed-model Analysis

The GLMM provided statistical support for patterns observed in the psychometric curves. We report the model's quality of fit (χ^2), relationship between fixed-effects and correct-response probability (β_G) and its associated strength (odds ratio, OR), and both the z and p values.

Offset axis and direction strongly improved model fit ($\chi^2(6)$ = 169.64, $p < 0.01$), supporting that offsets were not perceived equivalently. The axis × direction interaction was significant (β_G = -1.31, z = -10.93, $p < 0.01$), as was the offset × axis × direction interaction (β_G = -0.28, z = -2.31, p = 0.02), indicating that the effect of offset magnitude depended on both the axis and direction of the misalignment.

Offset magnitude was positively associated with correct-response probability (β_G = 0.47, z = 6.92, $p < 0.01$), indicating that larger camera-display offsets were generally easier to detect. Likelihood-ratio tests comparing the full model against reduced nested models showed that iris color significantly improved model fit ($\chi^2(2) = 28.43$, $p < 0.01$). The fixed-effect estimates indicated that light irises were associated with higher correct responses than dark irises (β_G = 0.30, z = 5.24, $p < 0.01$, OR = 1.36). The offset × iris color interaction was also significant (β_G = 0.13, z = 2.27, p = 0.02, OR = 1.14), suggesting that correct-response probability increased more steeply with offset magnitude for light irises than for dark irises.

Eyewear also significantly improved model fit ($\chi^2(2) = 13.88$, $p < 0.01$). However, this effect was smaller than the iris color and axis effects. The glasses coefficient was negative (β_G = -0.20, z = -3.50, $p < 0.01$, OR = 0.82), and the offset × glasses interaction was also negative (β_G = -0.12, z = -2.15, p = 0.03, OR = 0.88), suggesting that glasses were associated with reduced detectability in the model, and that detectability increased less steeply when glasses were present. Nonetheless, because the threshold curves did not show a uniform glasses effect across all axes and iris color combinations, this effect should be interpreted as statistically detectable but comparatively small and less consistent than the iris color effect. Finally, the stimulus set term was not significant (β_G = -0.05, z = -0.30, p = 0.77), providing no evidence of a global stimulus-set difference in the model.

Combination	Offset	*d [cm / degrees]*	α	β	λ
A1, B1	-X	-2.41 / -0.84°	-1.45	2.00	0.12
A1, B1	+X	2.71 / 0.94°	1.98	1.39	0.10
A1, B1	-Y	-2.93 / -1.02°	-1.72	1.57	0.14
A1, B1	+Y	NaN	1.03	1.47	0.27
A2, B2	-X	-4.39 / -1.52°	-3.51	1.76	0.12
A2, B2	+X	0.83 / 0.29°	0.79	1.75	0.05
A2, B2	-Y	-0.93 / -0.32°	-0.83	1.91	0.08
A2, B2	+Y	7.1 / 2.46°	7.10	1.62	< 0.01
A3, B3	-X	-6.29 / -2.18°	-4.00	1.03	0.17
A3, B3	+X	1.08 / 0.38°	0.96	1.93	0.05
A3, B3	-Y	-2.99 / -1.04°	-2.22	1.17	0.12
A3, B3	+Y	3.99 / 1.39°	4.00	1.47	< 0.01
A4, B4	-X	-1.12 / -0.39°	-0.95	2.03	0.09
A4, B4	+X	0.92 / 0.32°	0.76	1.47	0.13
A4, B4	-Y	-3.08 / -1.07°	-2.14	0.35	0.11
A4, B4	+Y	3.81 / 1.32°	3.06	1.55	0.05

Table 2: Parameters of sigmoid function and PoI with the 75% correct response line for both sets of videos, based on Equation 1. *Combination* indicates an specific variable permutation, as defined in §3.2. *Offset* specifies the spatial offset tested, where values can be left (-X), right (+X), down (-Y), or up (+Y). d represents the detectability threshold values; NaN denotes cases where the fitted sigmoid did not intersect the 75% correct response line. α, β and λ represent the sigmoid function parameters, fitted through least squares optimization.

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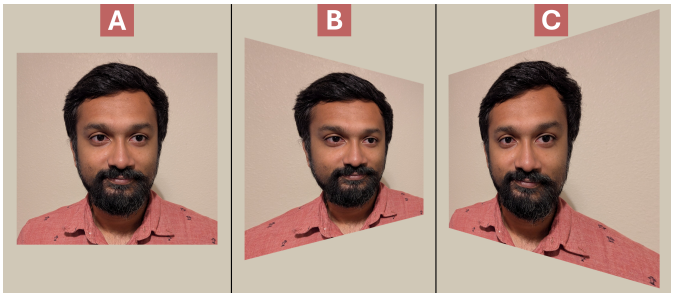


Figure 3: Geometric transformations as a low-cost technique to correct the perceived eye contact in MR. Panel A showcases the original image where the interlocutor is looking 8 cm to the left of the acquisition camera. Panel B showcases the result of applying a +35° 3D rotation to the 2D virtual panel. Panel C showcases the result of rotating the 2D panel by -50° instead. Panel C could be perceived as having better eye contact.

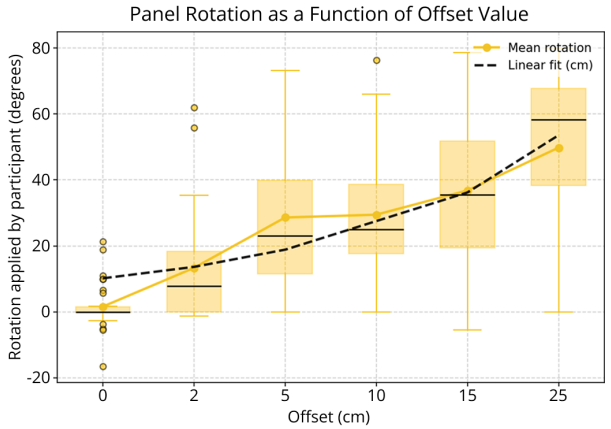


Figure 4: Rotation applied to restore perceived eye contact as a function of camera-display offset. Dashed line shows a least-squares linear regression between physical offsets and applied rotation.

6 Correction of Perceived Eye Contact

After quantifying how gaze misalignments disrupt perceived eye contact in MR, the question of how to correct the misalignments in MR telepresence remains. As mentioned in the Prior Work (§2.4), current videoconferencing approaches often rely on computationally expensive techniques or specialized camera setups. Unfortunately, such requirements are impractical for many MR systems due to hardware limitations, e.g., processing power, latency [14]. Instead, our approach is motivated by prior work relying on geometric transformations, usually less computationally expensive, to achieve eye and face rectifications [33, 34, 81].

We conducted an exploratory study of whether a 3D rotation of the interlocutor's 2D virtual panel could compensate for camera-display offsets and restore perceived eye contact. We used a continuous adjustment task: participants viewed pre-captured images of a single interlocutor (light irises with glasses) displayed on a virtual panel in MR. The images, acquired through the same setup of the previous experiment, corresponded to camera-display offsets of 0, 2, 5, 10, 15, and 25 cm. This task tested only rightward horizontal camera-display offsets (+X); no other offset direction was included. For each image, participants were instructed to rotate (yaw) the virtual panel until they felt the interlocutor was making direct eye contact (see Fig. 3). If eye contact could not be achieved for a given image, participants were allowed to skip that trial. The rotations were recorded in degrees, as well as instances where eye contact was not achievable. The viewing setup, MR environment, stimulus acquisition pipeline; power analysis, and display geometry were identical to those used in the previous experiment.

6.1 Results

Demographics: The study enrolled 30 participants. 80% of participants had used a MR headset before (never = 6, once = 9, several times = 11, once a week = 1, multiple times a week = 3); all of them had joined meetings using videoconferencing before (never = 0, once = 0, several times = 12, once a week = 1, multiple times a week = 17); and 90% felt comfortable engaging in eye contact with other people (strongly disagree = 0, disagree = 2, neither agree nor disagree = 1, agree = 13, strongly agree = 14).

Figure 4 illustrates the distribution of panel rotations applied by participants for each camera-display offset. **As the magnitude of the offset increased, participants generally applied larger rotations to the virtual panel**. The dashed line shows a least-squares linear regression between the physical offset (cm) and the applied rotation (degrees). It indicates an approximately linear relationship between camera offset and applied rotation (slope of 1.73 deg/cm).

Descriptive statistics for the applied rotations are summarized in Table 3. Both mean and median rotation values increased with offset magnitude. Skipped trials also increased as camera offsets grew larger. No trials were skipped for the 0 cm and 2 cm offsets, while higher offsets produced more skipped trials. Specifically, 6 trials (20%) were skipped at the 15 cm offset, and 7 trials (23.33%) at the 25cm offset, indicating that participants were more likely to report that eye contact could not be achieved at larger misalignments.

Offset (cm)	Mean ± SD Rotation	Median Rotation	Skipped	Skip Rate (%)
0	1.66 ± 7.15	0	0	0
2	13.37 ± 16.46	7.95	0	0
5	28.61 ± 21.54	23.13	1	3.33
10	29.46 ± 19.59	25.02	2	6.67
15	36.80 ± 23.04	35.52	6	20
25	49.75 ± 25.10	58.3	7	23.33

Table 3: Panel rotations applied by participants to restore perceived eye contact for each camera-display offset.

7 Discussion

7.1 General Findings

The combined detectability thresholds across stimulus sets (Fig. 5) reveal several patterns in how participants perceived eye contact in MR telepresence scenarios. When comparing combinations with and without glasses, the fitted sigmoid curves and their associated thresholds exhibit differences, particularly along the horizontal axis. In certain cases, such as in the light iris combinations, the presence of glasses appears to increase the tolerance to gaze deviations in one direction, producing wider detectability ranges. However, these effects are not consistent across all combinations.

Overall, variations associated with iris color (**RQ1**) appear more systematic than those associated with eyewear (**RQ2**). Across the combined combinations, participants generally exhibited clearer and more consistent detectability transitions when observing interlocutors with light irises compared to those with dark irises. In particular, the fitted sigmoid curves for light iris combinations tended to show steeper slopes near the threshold, indicating greater sensitivity to gaze deviations. A likely explanation is the increased contrast between the pupil and the iris in the light-colored eyes, which may make small gaze shifts easier to detect. Additionally, perceptual sensitivity differed depending on the axis along which the offset occurred (**RQ3**). Horizontal and vertical misalignments exhibited patterns in both magnitude and asymmetry, suggesting that eye contact perception in MR is influenced both by the magnitude of gaze deviation and its direction relative to the observer.

The supporting GLMM broadly corroborated these descriptive patterns: both iris color and eyewear improved the model fit. Nevertheless, the psychometric curves showed a more systematic iris color pattern and a less uniform glasses pattern. The axis/direction block also improved model fit ($p<0.001$), and the significant axis $\times$ direction interaction ($p<0.001$) supported the observed directional asymmetry.

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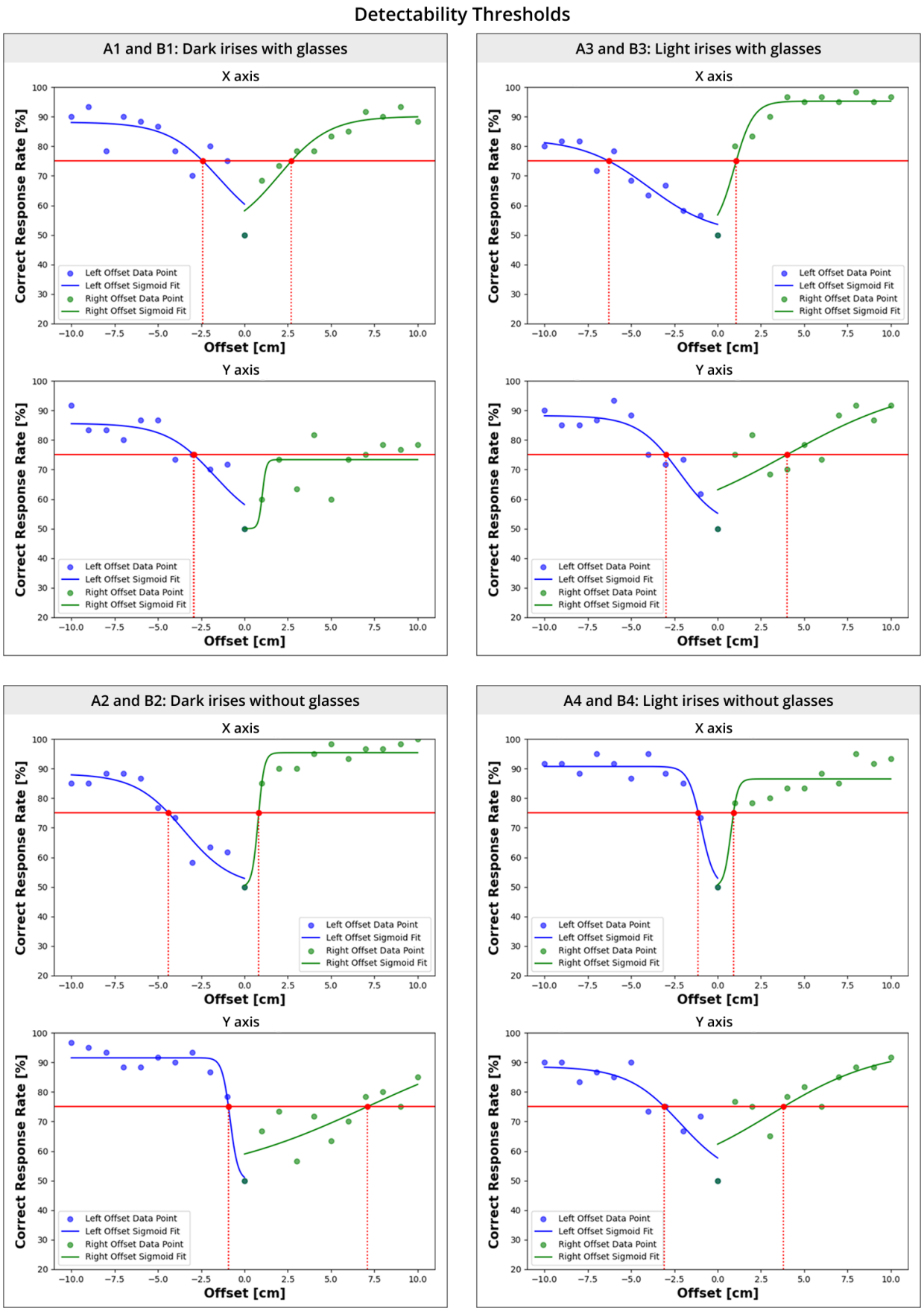


Figure 5: Perceived eye contact detectability thresholds across stimulus sets (Set A and B) and grouped by iris colors and presence of glasses.

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7.2 Findings Within Combinations

Dark irises - X Axis. For interlocutors with dark irises, participants exhibited asymmetrical sensitivity to gaze direction. In both combined dark-iris combinations, the detectability thresholds differed between the negative and positive X directions, indicating that participants tolerated larger deviations in one horizontal direction before perceiving a break in eye contact. The fitted sigmoid curves showed a more gradual transition near the threshold for negative offsets, suggesting a slower recognition of eye contact disruption. One possible explanation for this asymmetry lies in subtle morphological characteristics of the interlocutors. For instance, interlocutors I1 and I3 exhibited slight facial asymmetries and differences in eye shape that may have influences how gaze direction cues were interpreted [64]. Although further experiments would be required, prior research has shown that gaze perception relies not only on the eye region but also on broader facial context cues [40, 44].

Dark irises - Y Axis. In the combined dark-iris combinations, upward offsets were generally tolerated more than downward offsets, suggesting an asymmetry in vertical gaze perception. This indicates that participants were more sensitive to downward gaze deviations, while upward deviations could remain perceptually compatible with direct eye contact over a larger range of offsets. In the dark-iris-with-glasses condition along the positive Y direction, the fitted curve did not intersect the 75% correct response horizontal within the tested range. This suggests that offsets up to +10 cm were insufficient for participants to reliably detect a break in eye contact for this condition. Therefore, this case should not be interpreted as evidence of an unbounded tolerance, but rather as indicating that larger positive vertical offsets would be required to estimate the threshold reliability.

Post-experiment comments suggested that upward gaze deviations could appear to exhibit stronger eye contact because a larger portion of the sclera became visible. This observation suggests that the perception of eye contact may depend not only on gaze alignment but also on how eye morphology influences sclera visibility. In the case of interlocutor I1, the eyes were less round and had a mild downward tilt at the outer corners. Such characteristics may reduce sclera visibility in the video with no offset, making upward offsets appear more natural or direct.

Similar patterns have been observed in recent work on 2D displays. Gao et al. found that in videoconferencing-type settings while using a smartphone, people perceived eye contact more strongly when the gaze was directed slightly below the camera lens (around 2° visual angle), rather than exactly at it [21]. They attributed this effect to subtle changes in eyelid position and sclera visibility. Our observations align with this qualitative trend, although the magnitude of the effect differs, likely due to differences in display medium and the interlocutors.

Light irises - X Axis. For interlocutors with light irises, participants generally exhibited cleared threshold transitions along the horizontal axis. However, the degree of asymmetry differed across combinations, with the with-glasses combinations showing larger tolerance for negative X offsets than the without-glasses combinations. This suggests that while light irises may increase sensitivity to gaze deviations, the effect may interact with other visual factors.

Light irises - Y Axis. Vertical offsets for light irises also exhibited asymmetrical sensitivity. Detectability thresholds were larger for positive Y offsets than for negative Y offsets, indicating that participants tolerated larger upward gaze deviations before detecting a break in eye contact. The fitted sigmoid curves for positive offsets presented gradual slopes, suggesting that participants' ability to detect eye contact disruption improved progressively as offsets increased. Although the effect was less pronounced than in the dark iris combination, this behavior may again be linked to changes in sclera visibility as the gaze direction shifts vertically.

7.3 Findings Across Combinations

When comparing results across iris colors (**RQ1**), several notable trends emerge (see Fig. 5). Iris color influenced both the shape and slope of the fitted sigmoid curves, although the direction of this effect was not fully uniform across all offsets and combinations. In general, light-iris combinations exhibited clearer transitions near the threshold, whereas dark-iris combinations more often showed gradual or irregular response patterns. Positive X axis thresholds were relatively consistent across iris types, suggesting that gaze deviations in this direction were detected more similarly across combinations. In contrast, positive Y axis offsets showed greater variability, particularly in the dark-iris combinations, where the fitted curves failed to reach the 75% correct response line in one case, and the threshold estimates extended farther from the origin in the other. Overall, the results suggest that iris color influences how easily participants detect gaze misalignments, likely due to differences in visual contrasts and morphological differences.

7.4 Comparison of Individual Stimulus Sets

The individual stimulus sets reveal additional insights into how the eye contact perception varied across interlocutors. The fitted psychometric curves for the individual sets detailed in Appendices A and B provide information regarding the combined thresholds and illustrate how perceptual trends varied across interlocutors.

Set A. Results from Set A presented patterns largely consistent with the combined analysis. Horizontal gaze deviations produced clear detectability thresholds across all four combinations, indicating that participants were generally able to identify breaks in eye contact when offsets occurred along the X axis. In contrast, the vertical axis showed greater variability. Several combinations exhibited more gradual psychometric transitions, asymmetrical thresholds, or failed to reach the 75% correct response line, indicating that vertical gaze misalignments were perceived less consistently than horizontal ones.

Set B. Results from Set B also presented patterns broadly consistent with the combined analysis. Horizontal gaze deviations generally produced identifiable thresholds across combinations, indicating that participants were often able to detect breaks in eye contact when offsets occurred along the X axis. However, not all fitted curves reached the 75% correct response line. As in Set A, the vertical axis exhibited more varied behavior across combinations. Some curves showed asymmetrical thresholds, others gradual transitions, and in some cases the threshold occurred very close to zero offset.

It is important to note that the two stimulus sets contain different interlocutor identities and were therefore analyzed independently. As a result, differences observed between sets should not be interpreted as specific gender-related effects. Instead, these variations likely reflect natural differences in facial morphology, eye shape, or other visual cues that influence gaze perception. Future studies including a larger and more diverse set of interlocutors would allow for a more systematic investigation of how these factors modulate eye contact perception. The GLMM found no overall difference in correct-response probability between stimulus Sets A and B ($p = 0.766$). Thus, neither set was consistently easier to judge across conditions.

7.5 Contextual comparison to Prior Work on 2D Displays

The present study did not use identical stimuli across MR and non-MR environments, and therefore does not isolate the effect of MR itself. A direct comparison using the same stimuli across conventional displays and MR headsets remains an important direction for future work. Nevertheless, and leveraging eye contact trends found in prior teleconference works, our experimental setup reveals insights regarding how eye contact is sustained in MR telepresence systems.

Prior research on eye contact sensitivity in 2D displays for videoconferencing has shown that detectability thresholds vary depending on viewing direction and stimulus type. Tam et al. [65] examined four teleconsultation setups and found that a 7° gaze angle yielded stronger perceptions of eye contact than a 14° angle. Using rendered 3D head models, Macrae et al. [47] reported that the cone of gaze direction from which a person feels looked at subtends approximately 8.3° laterally. A subsequent study by Van der Pol [71] found that the region of perceived eye contact is mostly symmetrical, with a slight downward asymmetry of 0.5°, and overall 6.8° wide. Chen's study on videoconferencing [11] also highlighted strong directional asymmetries: observers tolerated larger offsets when gaze was directed downward, with thresholds as high as 7°, compared to horizontal or upward gaze where offsets closer to 1° were sufficient to disrupt perceived eye contact.

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Relative to these published reference ranges, thresholds in our MR configuration were generally smaller: 0.29°–2.18° horizontally and 0.32°–2.46° vertically, depending on condition (see Tab. 2 and Fig. 5). Because the study designs differ, these values should not be interpreted as evidence that MR causes greater sensitivity to gaze deviation. Instead, they position our estimates within the existing literature and motivate a controlled cross-display comparison. Our data also showed similar directional asymmetries noted by Chen and others, particularly along the vertical axis, where sclera visibility and interlocutor morphology appeared to shape perception [11], which suggests a potential shared perceptual pattern that could be explored in future work.

Additionally, other works have shown that both iris visibility and eyewear can influence how people judge eye contact. For instance, the presence of glasses can alter judgments of direct gaze in picture-based interactions [49], and iris color can interact with sclera visibility to affect gaze perception [83]. Our results indicate that iris color (**RQ1**) was associated with a more systematic pattern of eye contact detectability differences in the tested MR configuration, and that eyewear (**RQ2**) produced smaller and less consistent patterns across axes and iris color conditions. We emphasize that these findings should not be interpreted as evidence of differences between MR and conventional displays.

7.6 Correction of Perceived Eye Contact

Beyond quantifying the detectability thresholds, the exploratory study investigated whether geometric transformations could compensate for gaze misalignments in MR telepresence systems (addressing **RQ4**). Specifically, participants adjusted the rotation of the virtual panel displaying the interlocutor until they perceived direct eye contact.

Results indicate that panel rotation increased approximately linearly with camera-display offset, with a regression slope of 1.73° per centimeter of offset. This suggests that users intuitively applied larger rotations as the gaze misalignment increased, attempting to restore perceived eye contact through geometric alignment. For moderate offsets, this approach appeared effective. Participants were generally able to find a panel orientation that restores the perception of eye contact. However, as offsets increased, the variability of the applied rotations also increased, and participants began to report that eye contact could no longer be achieved. This is reflected in the increasing number of skipped trials for the largest offsets.

These findings suggest that geometric transformations may serve as a lightweight method for compensating moderate gaze misalignments in MR telepresence systems. Compared to approaches based on complex gaze redirection algorithms or specialized camera setups, rotating the virtual display surface may offer a simpler alternative that can be implemented with minimal computational cost. However, the results also indicate that such corrections have practical limits, and large camera-display offsets may still disrupt eye contact perception even when geometric compensation is applied.

Our observations are consistent with prior work suggesting that geometric manipulations of the displayed image can influence perceived gaze direction in video-mediated communication. Jaklič et al. [34] proposed that rotating the image of a videoconferencing partner around the horizontal axis can improve the subjective experience of eye contact by exploiting psychophysical properties of gaze perception. Their experiments showed that moderate rotations of the image plane could partially compensate for the typical camera-display offset present in videoconferencing systems. Although their approach relied on rotating the image of the interlocutor rather than the display surface itself, the underlying principle is similar: small geometric transformations can alter the perceived gaze direction and thereby mitigate eye contact errors. Our exploratory findings extend this idea to MR telepresence systems by showing that participants intuitively apply comparable geometric adjustments when attempting to restore perceived eye contact.

8 Conclusion, Limitations & Future Work

This work quantified the detectability thresholds for perceived eye contact in MR telepresence and identified factors that may modulate them. By addressing our research questions, several implications emerged:

RQ1 (iris color): The psychometric thresholds, supported by the GLMM, indicate that eye contact detectability was associated with iris color in the tested stimuli. Participants exhibited more defined and consistent detectability thresholds when observing interlocutors with light irises, suggesting greater sensitivity to small gaze deviations. In contrast, dark irises often produced more gradual response patterns and asymmetries in detectability. These findings suggest that future MR systems, especially those involving avatars, video-based representations or nonverbal cues, should consider iris color and eye-region contrast as factors that may influence the perception of gaze direction.

RQ2 (presence of glasses): The GLMM identified a statistically detectable association between glasses and reduced detectability, but the psychometric thresholds did not show a uniform effect across axes and iris-color conditions. We therefore interpret clear prescription glasses as a smaller and less consistent factor than iris color in the tested configuration, rather than as irrelevant. Other eyewear types and lens coatings may yield different effects.

RQ3 (horizontal vs. vertical offsets): The psychometric thresholds and supporting GLMM indicated differences between horizontal and vertical fixation offsets. Horizontal gaze deviations generally produced clearer and more consistent detectability thresholds across combinations, whereas vertical offsets often presented greater variability and asymmetrical patterns. In several cases, participants tolerated larger upward gaze deviations than downward ones, which we hypothesized is related to morphology and sclera visibility. Moreover, thresholds and rates of change varied depending on the direction of the offset, suggesting that the perception of eye contact is not symmetrical across spatial directions. These findings indicate that vertical and horizontal fixation offsets should not be treated equivalently in MR system design, and that gaze corrections should account for these directional differences.

RQ4 (geometric correction): The exploratory study investigated whether geometric transformations could compensate for gaze misalignments in MR telepresence systems. Results showed that the applied panel rotations increased approximately linearly with the the magnitude of the camera-display offset. While this approach appeared effective for moderate offsets, larger misalignments were more difficult to compensate and often resulted in skipped trials. This suggests that lightweight geometric transformations may partially mitigate gaze offsets in MR systems, although their effectiveness may be limited.

While only four interlocutors were recorded, this subset was sufficient for testing the iris color and glasses. We acknowledge that the small sample limits generalizability across populations; however, these attributes have been shown to influence eye contact perception in prior studies. Other limitations include the controlled recording environment and reliance on prerecorded videos, which do not capture the full range of dynamics present in live interactions. Future work should expand to a broader set of interlocutors to increase diversity across features, and include more interaction contexts. Furthermore, future work should explore dynamic gaze correction systems that consider not only camera and display alignment, but also user-specific perceptual sensitivities.

Lighting was held constant, but corneal reflections could still vary with gaze direction and were not modeled as an independent factor. Such highlights may provide additional cues for judging eye contact, particularly for vertical offsets. Future studies should manipulate lighting—including common videoconferencing setups such as ring lights—to explore effects on eye-region contrast and perceived gaze direction. Our stimuli was generated by varying gaze fixation while keeping camera position, head pose, and facial perspective constant. This allows precise control over gaze misalignment, but does not exhaustively reproduce all real webcam and monitor configurations. In practical systems, camera-display offsets may also change head pose, facial perspective, and the apparent direction of attention. Future work should examine a broader set of acquisition geometries, including camera placement, and natural head movements during live interaction.

Ultimately, improving the fidelity of eye contact in MR communication has the potential to strengthen social presence, enhance collaboration, and support more natural interpersonal interactions in remote settings; more researchers should extend their efforts towards the unanswered questions in the field of eye contact in MR telepresence.

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