Making Eye Contact Accessible: Augmenting Gaze in Job Interviews for People with Visual Impairments

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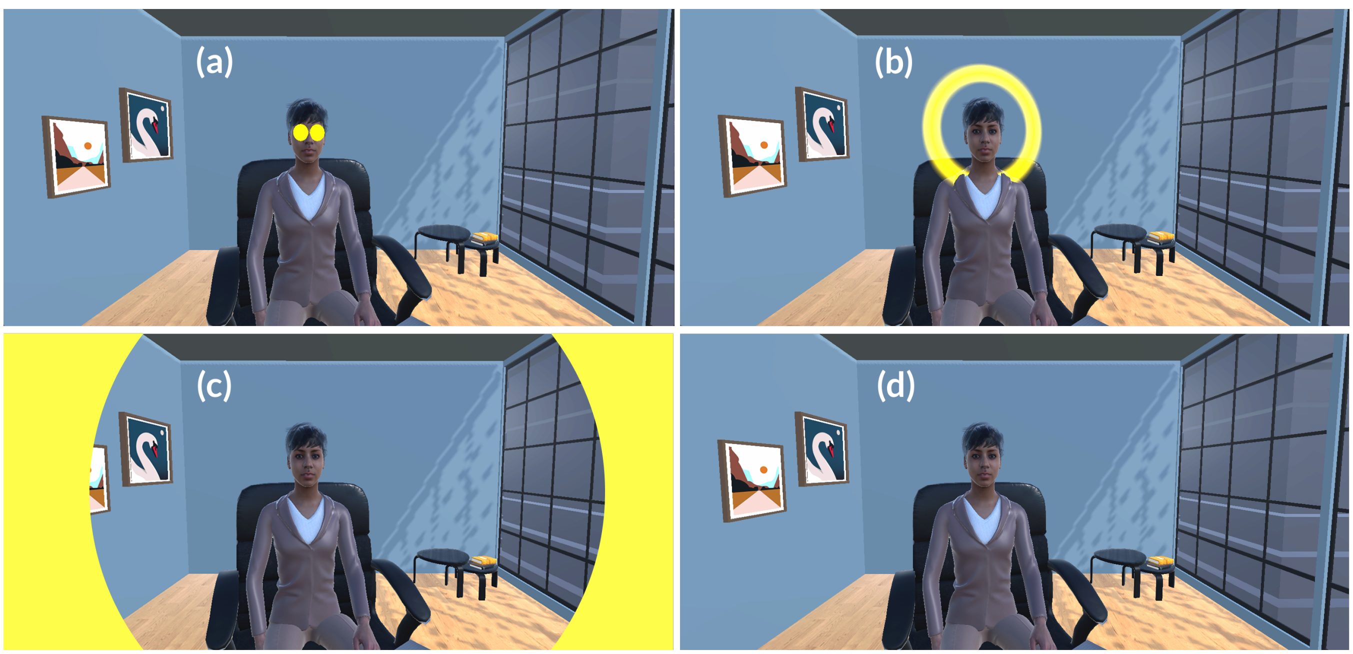

Figure 1: The four conditions of displayed cues, starting on the top left in read direction: (a) EYES, consists of two spheres attached to the interviewer, hovering in front of the interviewer's eyes; (b) HALO, a ring around the interviewer's head; (c) FRAME, consisted of a frame attached to the headset's field of view; (d) NONE, the baseline condition, where no cue is visible. For all three cues in this figure, the second level of size, maximum opacity, and yellow color were pre-selected.

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Abstract

Job interviews rely heavily on nonverbal communication, with gaze serving as a central signal of attentiveness and competence. For people with visual impairments, this creates an asymmetry that disadvantages them: they are expected to demonstrate eye contact but cannot access or reciprocate the gaze cues that structure interaction. To investigate these challenges in a high-stakes context, we conducted interviews with eight people with visual impairments, revealing how inaccessible gaze produces uncertainty, social pressure, and reliance on compensatory strategies. Based on these insights, we designed three visual cues, EYES, HALO, and FRAME, and evaluated them in a simulated job interview in virtual reality with 12 people with visual impairments. Our findings show that spatially anchored cues around the interviewer's face supported head alignment and improved perception of attentional focus, while peripheral cues were distracting. The study highlights the need for gaze cues that strike a balance between perceptual accessibility and social appropriateness in professional settings.

CCS Concepts

• **Human-centered computing** → *Accessibility technologies.*

Keywords

Visual Impairment, Low Vision, VR, Eye Contact, Assistive Technology

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1 Introduction

In face-to-face conversations, nonverbal behavior conveys subtle but influential cues. During job interviews, these cues shape impressions, signal confidence, and affect how candidates are evaluated, often making the interaction less about what is said and more about how it is said. For example, nonverbal behaviors such as eye contact and body orientation have been associated with an increased likelihood of receiving a job offer [24]. Among these nonverbal behaviors, eye contact is one of the strongest predictors of perceived performance and interview success [16, 37]. Candidates who maintain direct eye contact are more likely to be perceived as intelligent, credible, and employable [3, 10, 53]. However, for people with visual impairment, eye contact remains largely inaccessible, both in terms of perceiving the interviewer's gaze and expressing their own. This creates a fundamental asymmetry in a setting where gaze has a strong influence on outcomes.

Prior work explored ways to make gaze and other nonverbal cues accessible for people with visual impairments. For example, notifications about eye contact have been shown to support timing and orientation [29, 54], and studies indicate that people with visual impairment report benefits from visual feedback when available, alongside nonvisual strategies [36, 47, 58], yet presenting information simultaneously across sensory channels can lead to sensory overload [29, 54].

Still, challenges remain: the gaze must not only be perceptible but also interpretable within the social flow of interaction. Recent work highlights that attentional signals are understood through a combination of modalities such as voice, head orientation, and timing [27, 28]. Moreover, assistive technologies influence confidence, stigma, and social dynamics, showing that design must balance functional access with social meaning [2, 17, 25, 39, 48, 49]. Despite these advances, little is known about how gaze inaccessibility is experienced in high-stakes contexts like job interviews, and what kinds of cues would be considered socially meaningful and usable.

Building on this motivation, we conducted semi-structured interviews with eight individuals with visual impairments to understand their experiences with gaze during job interviews. Based on these insights, we designed three visual cues to indicate when an interviewer was looking at the participant: *EYES* (markers at the interviewer's eyes), *HALO* (a ring around the head), and *FRAME* (a frame anchored to the headset's field of view). We then implemented these cues in a Virtual Reality (VR) job interview simulation and conducted an exploratory study with 12 participants with visual impairments. This approach is novel in applying spatially anchored gaze cues to the formal, evaluative context of job interviews, where gaze expectations are heightened, and social stakes are high.

Our results show that augmenting visual gaze cues can help people with visual impairment orient toward a conversational partner, particularly when cues are spatially anchored near the source of gaze. The *EYES* and *HALO* conditions tended to support stronger head alignment and were rated as more helpful and socially appropriate, while *FRAME* was often perceived as distracting. These findings suggest that gaze cues must be both perceptually accessible and socially meaningful to support inclusion in formal settings. More broadly, our work contributes design considerations for customizable, context-sensitive gaze cues to reduce asymmetries in nonverbal communication and promote equity in job interviews and beyond.

1.1 Contribution Statement

This paper makes three contributions to accessibility and HCI. First, we analyze how people with visual impairments experience gaze in job interviews, revealing that inaccessible gaze creates performative pressure, uncertainty, and emotional strain that extends beyond perceptual barriers. Second, we design and evaluate three visual gaze cues, *EYES*, *HALO*, and *FRAME*, based on participants' lived experiences. Our VR study with persons who have visual impairments reveals that spatial anchoring influences head alignment and perceived attentiveness. Third, we derive design considerations for inclusive gaze support that emphasize customizable, socially meaningful cues for formal contexts where equity is a priority. These contributions advance assistive systems from making gaze visible to fostering social connection and reducing interpersonal asymmetry.

2 Related Work

Our work is based on assistive technology for social interaction, in particular making facial expressions or eye contact perceivable, which we summarize below.

2.1 Assistive Technologies for Spatial and Emotional Awareness

In social interactions, it is essential for people with visual impairment to understand where their conversation partner is located in space relative to themselves [33]. To address this need, researchers have developed algorithms for person localization and wearable prototypes aimed at making nonverbal cues more accessible [18, 33]. Several assistive technologies use alternative sensory modalities, such as touch or sound, to convey spatial information. For instance, one system used a haptic belt with vibrating rhythms to signal interpersonal distance [38], while another provided directional information through voice feedback [4]. Although participants generally appreciated the additional awareness these tools offered, concerns around social acceptability often limited their willingness to use such devices in public.

In virtual environments, researchers have combined spatial division with distance-based audio cues to convey the proximity of others [26]. This represents a distinct strategy for encoding proximity in VR, differing from the visual cue approach explored in our work. Auditory cues can support people with visual impairment in detecting emotional tone, yet facial expressions remain largely inaccessible [43]. To expand access to emotional expressions, lightweight facial expression recognition has been developed for low-power devices [45], making it suitable for integration into portable or wearable assistive technologies. Other approaches leverage haptic and auditory feedback, such as wearable belts that represent emotional states, though these often rely on arbitrary signal mappings that require training [9]. Additional tactile systems include gloves that convey haptic "emoticons" and chairs using vibration patterns to represent different emotions [32]. More recently, Komoda et al. [31] introduced an auditory interface that maps facial expressions to musical patterns, supporting empathic synchronization between blind and sighted partners.

While Augmented Reality (AR) has supported people with visual impairments in tasks like navigation [23, 57], object recognition [58], touchscreen interaction [34], and magnification [46], only a few studies have examined its use for conveying nonverbal cues in direct social interactions. For instance, Lang et al. [35] used AR to visually display emotional expressions to people with visual impairment.

Overall, prior assistive systems illustrate the potential of conveying nonverbal cues, but they have rarely been studied in formal interview settings. We therefore use VR as a controlled testbed to prototype and compare gaze cues for a simulated job interview. This setup lets us vary placement, timing, and salience while keeping the context fixed, clarifying cue effects and providing a basis for later AR adaptations.

2.2 Accessing Gaze

Prior work has also addressed the perception of eye contact for people with visual impairment. For example, one system uses a vibrotactile belt to assist users in discerning gaze direction by vibrating on the side corresponding to where a person is looking [44]. The Microsoft PeopleLens, designed for blind children, is a head-worn device that detects individuals' positions and gaze direction [40]. When the child faces someone, their name is spoken, and a flashing LED signals successful identification to sighted individuals. Additional auditory cues convey gaze direction, helping the child establish eye contact. A recent evaluation of the PeopleLens by Jones et al. [27] highlights both the potential and challenges of such assistive technologies. Their study, which includes blind and sighted children, shows that while spatialized audio cues can support social attention, they must be carefully designed to align with context and user expectations in order to avoid confusion or disruption in social interactions.

Qiu et al. [42] developed a glasses-like device that simulates mutual gaze to manage turn-taking in dyadic conversations. It offers two modes: *while-speaking*, where the glasses alternate gaze direction to simulate natural speaker behavior [5], and *while-listening*, where they maintain mutual gaze. This simulation had a positive impact on co-presence, perceived attention, and conversational engagement. In a follow-up, the device was extended with a tactile wristband that vibrates when the conversation partner looks at the user [41]. This feedback improved users' confidence and willingness to speak by signaling attentional focus.

Gaze cue systems have also been explored in VR. For example, Collins et al. [12] worked with a blind designer to create audio and haptic versions of gaze. They found that subtle sounds were especially helpful and did not interrupt the conversation. Their work highlights the need for customizable gaze cues in social VR. Jung et al. [29] expanded on this by evaluating how people with visual impairment interpret nonverbal behaviors in VR. They used auditory and haptic cues and found an improvement in users' ability to judge attentiveness. Their findings emphasize the importance of timing, clarity, and multimodal support. Similarly, a recent study explored different sensory modalities to deliver gaze cues in social VR [54].

We conclude that current research offers promising building blocks, including tactile and auditory feedback, gaze simulation, and VR-based approaches. Among these, real-world prototypes like the vibrotactile belt [44], PeopleLens [27, 40], and the glasses by Qiu et al. [41] rely on simple cues to indicate when someone is being looked at, whereas VR settings [12, 29, 54] enable greater variation.

However, it remains unclear how these techniques perform in high-stakes contexts, such as job interviews. While prior work has explored spatialized gaze cues in informal or educational settings, our contribution lies in adapting and evaluating such cues in the socially demanding context of job interviews. This context introduces distinct design pressures, such as formality and impression management, which remain underexplored in current accessible gaze design. Our work builds on these foundations by investigating how spatially anchored visual gaze cues can support social orientation and perceived attentiveness in formal scenarios.

3 Formative Study

We conducted a formative interview study with eight persons with visual impairments to explore their experiences of gaze during job interviews. Our aim was to identify key challenges and design-relevant insights to guide the subsequent cue design and VR evaluation.

3.1 Participants and Procedure

We recruited eight individuals with visual impairment (4 identified as female, 0 as diverse, and 4 as male) with ages ranging from 22 to 57 years through individual outreach efforts within our private network and social media, as shown in Table 1 with ID PInt. Participants were eligible for the interview if they had a visual impairment that affected their ability to perceive facial details of a conversation partner in a seated conversational setting and had experienced at least one job interview.

An independent ethics committee approved the study. We conducted individual semi-structured interviews lasting 60 to 90 minutes via Zoom or Discord. Participants received a consent form with information on privacy and rights and were free to withdraw or skip questions, though none did. We recorded all sessions and transcribed them for analysis. Participants received financial compensation (13 USD/hour).

We collected demographic data and focused the interview on: *gaze behavior in job interviews.* Participants shared their experiences, expressions, and interpretations of gaze in these settings, as well as the meanings they associated with it.

3.2 Data Analysis

The interviews were conducted by the second author and analyzed in close coordination with the first author through regular discussions. We followed a primarily deductive, question-driven thematic analysis inspired by Braun and Clarke [8], rather than a fully reflexive thematic analysis. We disregarded repeated statements from the same participant as we were not interested in the quantity of statements of one individual, but in the essence of the statements. We began with open coding, developing an initial coding framework that was closely aligned with the interview guide. We then iteratively refined and clustered codes using affinity mapping to derive more abstract concepts and patterns. We therefore treat our approach as a structured, predominantly deductive use of thematic analysis.

3.3 Findings – The Role of Gaze Behavior

We present participants' perspectives on gaze behavior in job interviews. It is important to clarify that participants in our study strongly linked head and body orientation with gaze. At the time of the interviews, none of the participants could perceive their conversation partners' gaze behavior, and only PInt-8 had this ability in the past. Below, we present our findings on (1) Importance of Gaze, (2) Perceiving Gaze, and (3) Expressing Gaze.

Importance of Gaze. When asked about the importance of gaze in job interviews, participants reported three key functions. Seven described gaze as a signal for attention and interest. PInt-5 summarized its value: *"I believe that when I'm in a job interview and talking to someone, I have the right to their full attention [expressed through gaze], and if I expect that, then I should also reciprocate [the same gaze behavior] to everyone who engages in these conversations."* Conversely, avoiding eye contact was seen as disinterest (PInt-2, PInt-3) or even disrespect (PInt-4, PInt-5, PInt-8). PInt-4 explained: *"Well, I think that's super disrespectful, especially in an interview, when you're actually talking to each other, but the person is looking somewhere else, then I find that strange."*

Four participants described gaze as a tool to convince others, such as PInt-2, who said, *"When I think I can wrap him around my finger, I try to open my eyes and look deep into his eyes."* Two participants also linked gaze to cognitive ability (PInt-2, PInt-8). As PInt-2 stated, eye contact made individuals appear more alert, while PInt-8 noted: *"When someone cannot make eye contact with others, I'd say there's something strange about them, whether it's due to a specific [cognitive] reason or some other cause."* [1]

Six participants emphasized that their understanding of gaze was shaped by past experiences of feeling ignored when eye contact was missing. PInt-8, who lost vision ten years earlier, added that his understanding stemmed from previous experience with sighted people and the emotional signals eye contact conveys. Additionally, six participants mentioned external influences. PInt-6 stated, *"I believe that it is a very important component for sighted people. There are also proverbs somehow saying the eyes are the window to the soul."* This view was shared by PInt-1, PInt-4, PInt-5, and PInt-7. Two participants (PInt-2, PInt-6) said they learned the social meaning of gaze, such as conveying interest and emotion, from sighted individuals. In summary, participants attributed three primary functions to gaze: signaling attention and interest, persuasion, and reflecting cognitive ability. Their understanding was shaped by personal and social experiences. Avoiding eye contact was often interpreted as a sign of disinterest or disrespect.

Perceiving Gaze. Participants commonly equated gaze with head orientation. Six participants inferred gaze direction from cues such as head movement (PInt-4), head outline (PInt-2), or voice direction (PInt-4, PInt-5, PInt-6). Still, specific gaze behavior was inaccessible to most (PInt-1, PInt-2, PInt-4, PInt-6, PInt-8). PInt-7 assumed interviewers were always looking at her during interviews.

When asked whether they wished to perceive gaze, PInt-5 questioned its difference from head orientation: *"Is eye contact behavior different from perceiving the head orientation?"* Seven others, however, wanted to perceive gaze to gain insight into their conversation partner's mental state. PInt-8 noted, *"you can recognize many things that are not necessarily spoken, as communication often relies solely on looks."* Four participants (PInt-1, PInt-4, PInt-6, PInt-8) expressed interest in perceiving gaze to detect attention and interest, while five highlighted its potential to reveal emotions (PInt-2, PInt-3, PInt-4, PInt-7, PInt-8) and reactions (PInt-2, PInt-4, PInt-7).

However, participants without prior visual experience noted the need to first learn how to interpret gaze (PInt-6). Four also described alternative strategies to infer mental states, mainly through voice (PInt-2, PInt-6, PInt-7) or by asking directly (PInt-8). In summary, participants closely associated gaze with head orientation but lacked access to actual gaze behavior. While one participant noted little difference, most valued the potential of perceiving gaze for social understanding.

Expressing Gaze. Six participants reported intentionally directing their gaze toward their conversation partner's face or general direction (PInt-1, PInt-3, PInt-4, PInt-5, PInt-6, PInt-8). PInt-3 and PInt-8 said they received feedback from sighted individuals who did not realize they could not establish precise eye contact.

While many participants described strategies for managing eye contact, four reported specific challenges related to concentration (PInt-1, PInt-5), light sensitivity (PInt-2), or an inability to focus

[1] While participants acknowledged internalized societal norms linking gaze behavior with cognitive competence, such associations reflect broader ableist misconceptions. Though not the focus of this work, these beliefs merit critical examination in future research and inclusive hiring practices.

Table 1: Demographic information, participation, condition, and self-reported visual acuity of the participants.

ID*	Participation	Gender & Age & Onset	Condition	Residual Vision (%)**
PInt-1	Interview, User Study	m, 20-30, birth	Cone dystrophy	8–12
PInt-2	Interview	m, 30-40, birth	Nystagmus, albinism	4–8
PInt-3	Interview	f, 20-30, birth	Glaucoma	blind
PInt-4	Interview, Pilot Study	f, 20-30, birth	Achromatopsia	10–15
PInt-5	Interview	m, 50-60, birth	Optic nerve atrophy	0–2
PInt-6	Interview	f, 20-30, birth	Cataract, glaucoma	0–30
PInt-7	Interview	f, 50-60, birth	Cataract, nystagmus	5
PInt-8	Interview	m, 30-40, later	Leber Hereditary Optic Neuropathy	2–3
Pilot-1	Pilot Study	f, 30-40, birth	Cone dystrophy	5–7
Pilot-2	Pilot Study	m, 20-30, birth	Leber congenital amaurosis	3
Pilot-3	Pilot Study	f, 20-30, later	Stargardt disease	< 1
PStudy-1	User Study	f, 20-30, birth	Idiopathic intracranial hypertension	3
PStudy-2	User Study	f, 50-60, birth	Achromatopsia	10
PStudy-3	User Study	f, 40-50, birth	Cone dystrophy	5–8
PStudy-4	User Study	m, 40-50, later	Cone dystrophy	2–10
PStudy-5	User Study	f, 50–60, birth	Astigmatism	< 1
PStudy-6	User Study	m, 30-40, birth	Bardet-Biedl syndrome	3
PStudy-7	User Study	m, 20-30, later	Cone dystrophy	2–5
PStudy-8	User Study	f, 30-40, later	Optic nerve atrophy	10–15
PStudy-9	User Study	m, 40-50, later	Cerebral visual impairment (multiple sclerosis)	2–5
PStudy-10	User Study	f, 60-70, later	Macular degeneration, glaucoma	0–10
PStudy-11	User Study	m, 50-60, birth	Retinitis pigmentosa	4–6

*PInt stands for participant interview, Pilot for participant in the pilot study, and PStudy for participant in the user study. PInt-1 participated in both the interview and the user study. PInt-4 participated in both the interview and the pilot study. For both participants, we assigned the ID based on their first participation. **The participants described their residual vision as fluctuating and dependent on their daily condition.

due to vision loss (PInt-8). Two also mentioned shyness (PInt-3) or inhibition (PInt-7). Four participants said they had to learn eye contact, starting in school (PInt-3, PInt-5) or at work (PInt-2).

Another four described alternative strategies to signal attention: nodding (PInt-3), adjusting posture (PInt-1, PInt-7), and using gestures or facial expressions (PInt-4). In summary, participants generally tried to make eye contact, though some had to learn how and many faced difficulties. As a result, they developed alternative strategies to express engagement.

3.4 From Interview Insights to Cue Design

Our interviews revealed that an inaccessible gaze in job interviews is not only a perceptual challenge but also a social barrier tied to attention, respect, and competence. Candidates described the performative pressure of appearing attentive without reciprocal feedback, often relying on compensatory strategies such as head orientation or posture. Guided by these findings, we designed three visual gaze cues, *EYES*, *HALO*, and *FRAME*, alongside a baseline condition with no cue (*NONE*). Each cue was grounded in specific interview insights about how participants perceive or express gaze (Table 2).

3.4.1 EYES: Responding to the Need for Precision. The *EYES* cue (Figure 1a) placed two markers directly in front of the interviewer's eyes. Participants emphasized a desire for precise confirmation of being looked at, reflecting the strong social value they attributed to mutual gaze in signaling attentiveness and competence. EYES addressed this by offering exact feedback at the source of gaze.

3.4.2 HALO: Leveraging Head Orientation as Proxy. The *HALO* cue (Figure 1b) encircled the interviewer's head. Participants frequently equated gaze with head orientation, using coarse cues such as head outline or movement to infer attention. HALO built on this natural strategy, providing an intuitive and socially meaningful indicator of attentional focus.

3.4.3 FRAME: Supporting Peripheral Strategies. The *FRAME* cue (Figure 1c) was anchored in the user's field of view, detached from the interviewer's body. This design was motivated by participants with central vision loss or those relying on peripheral strategies (e.g., voice direction). They highlighted the need for broader and more perceivable signals, even if less tightly coupled to the interviewer's body.

3.4.4 Design Principles: Adaptability and Simplicity. Beyond specific cues, the diversity of participants' visual profiles highlighted the importance of adaptability. We enabled customization of size, opacity, and color (with four levels each), allowing users to enhance visibility or reduce intensity depending on acuity, glare sensitivity, or peripheral vs. central vision. In addition, some participants noted difficulty interpreting subtle or continuous gaze behaviors; we therefore simplified feedback into two discrete states: eye contact or no eye contact to reduce cognitive load under interview pressure.

4 User Study

The goal of the study was to evaluate how visual cues, developed from insights in our formative interviews, can support people with visual impairments in perceiving and responding to an interviewer's

Table 2: Linking interview insights to the design of the gaze cues.

Cue	Interview Insight	Design Rationale
EYES	Participants wanted precise confirmation of being looked at and valued mutual gaze as a strong social signal of attention, respect, and competence.	Two markers placed directly at the interviewer's eyes provided exact feedback about eye contact, reinforcing the social meaning of mutual gaze in high-stakes interactions.
HALO	Participants commonly equated gaze with head orientation and relied on coarse proxies (head outline, movement, or voice direction).	A ring around the head visualized attentional focus in a socially intuitive way, aligning with participants' existing strategies while remaining less intrusive.
FRAME	Participants with central vision loss or alternative strategies emphasized the need for broader, perceivable signals beyond the face.	Anchoring the cue in the user's field of view detached it from the interviewer's body, making the signal more globally visible even if central fixation was not possible.

attention during job interviews. We used VR as a testbed to prototype AR-plausible gaze cues. VR simplifies identical scenes and interview timing across conditions, counterbalanced trials without environmental variance, and a safe and ethical rehearsal of a high-stakes scenario. Further, we intentionally presented only visual cues to isolate channel effects and to support people with visual impairments who prefer visual feedback when available [36, 47, 58].

4.1 Experiment Design

We employed a within-subjects experimental design. The independent variable was Cue Type with four levels: *EYES*, *HALO*, *FRAME*, and *NONE*. To minimize order effects, the presentation of conditions was counterbalanced across participants using a balanced Latin square design [51].

4.2 Participants

We conducted the user study with 12 participants with visual impairment (6 identified as female, 0 as diverse, 6 as male), aged between 22 and 67 years, through individual outreach within our private network and social media (see in Table 1 with ID PStudy). Sessions took place in Germany and in Spain, with the Spanish sessions hosted by the organization Once in Valladolid, which also supported participant recruitment. We applied the same participation criteria as used for the interview. The participants were financially compensated and signed the informed consent form before the interview. We received approval from an independent ethics committee. Participants had diverse visual profiles, including central vision loss, peripheral field loss, and mixed impairments. This heterogeneity shaped how different cues were perceived and limits the extent to which our findings can be generalized to all people with visual impairments.

4.3 Simulated Gaze and Avatar Behavior

The avatar followed distinct gaze patterns for speaking and listening, based on established findings that speakers make less eye contact than listeners [5, 30]. Prior work on virtual agents also applied longer gaze during listening [7, 20], and turn-taking strategies for visual impairment [42].

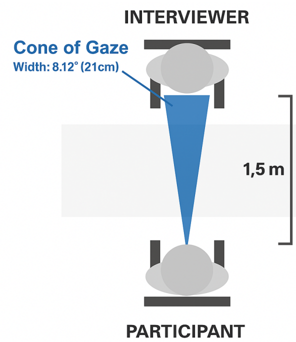

Figure 2: The visualization offers an overhead view of the VR scene, where two avatars, the interviewer and participant, sit 1.5 meters apart with a table between them. The cone of gaze marks the horizontal region where the participant's gaze is perceived as "look-at" by the interviewer, while gazing beyond it is seen as "look-away."

We refined the implementation through pilot testing with four participants with visual impairment (see Table 1). The initial Wizard of Oz prototype [14] was replaced by automated cue control after feedback indicated that manual triggering and pulsing were distracting.

Cue durations were sampled from predefined time ranges for speaking and listening (Figure 3) to maintain natural variation and avoid repetitive timing. Cues were activated at speech onset and removed at speech offset. To preserve stimulus control, the avatar used minimal animations in both states, allowing us to isolate the perceptual impact of the cues.

4.4 Procedure

The user study was conducted in person and lasted about 60 to 90 minutes per participant (see Figure 4). Participants were informed about the study's objectives, procedures, and confidentiality terms. We began by explaining the study phases to the participants and then assisted them in putting on the HTC Vive Pro Eye VR headset.

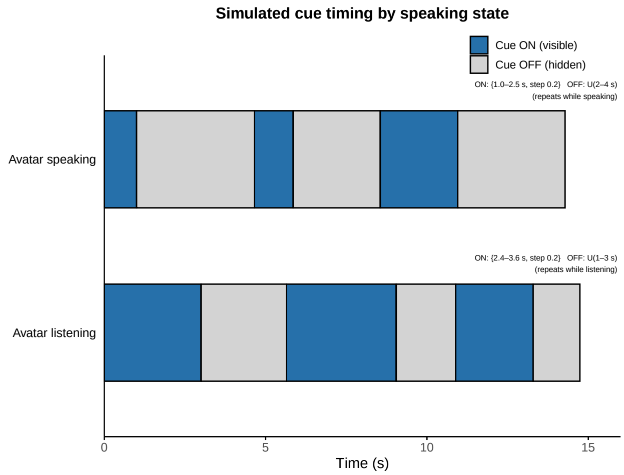

Figure 3: Illustration of the simulated cue timing for the avatar while speaking and listening. During speaking periods, cue-on durations were sampled uniformly from discrete values between 1.0s–2.5s (0.2s steps), and cue-off durations from a continuous uniform range of 2s–4s. During listening periods, cue-on durations were sampled from discrete values between 2.4s–3.6s (0.2s steps), and cue-off durations from a 1s–3s uniform range. The small overlap between the speaking (1.0s–2.5s) and listening (2.4s–3.6s) cue-on ranges (2.4s–2.5s) introduced variability across states and reduced the risk of overly regular, robotic timing.

Then, participants encountered the four conditions in counterbalanced order. They were briefed on customization options for each cue variant, which were adjusted according to their preferences to accommodate medical conditions such as light sensitivity or central vision loss (see supplemental material for all options selected by each participant). These customization features were informed by the interview findings, which revealed diverse visual profiles across participants, including differences in contrast perception, central versus peripheral vision, and glare sensitivity. The customization parameters (size, color, opacity) were designed to reflect this diversity and to allow users to adapt the cues to their own visual abilities. This approach follows established practices in accessibility research, where all design options are introduced before testing to ensure participants can meaningfully compare them [34, 56–58].

Participants engaged with each cue condition in the same order as during customization, with each block containing a set of pre-scripted and pre-recorded interview questions (see supplemental material). The 16 questions were divided into four sections: background and education, skills and competencies, behavior and experience, and role and industry perspective, each represented by four questions, with one block corresponding to each of the four conditions. We instructed participants to respond as they would in a real job interview and to answer the interviewer's questions authentically. We explained that whenever the cue was visible, it signaled that the interviewer was looking at them. Advancement to the next question was manually triggered by the experimenter via key press only after the participant had finished their response, ensuring consistent pacing without truncating answers.

After completing each block, participants removed the VR headset and answered questions on attention, as well as providing qualitative feedback on design improvements. This process was repeated for each cue condition. At the end, participants answered three final questions on the usefulness of the approaches and received 13 USD/hour for their participation.

4.5 Measurements and Data Analysis

We combined behavioral, subjective, and qualitative measures. Due to the small and diverse sample, all quantitative analyses were exploratory, focusing on the direction of effect and variability. We reported bootstrapped 95% confidence intervals to estimate mean differences and illustrate uncertainty [13, 15]. We obtained all confidence intervals using non-parametric bootstrapping with 10.000 resamples (see supplementary material).

Head Orientation. We measured head orientation during the simulated interview to assess responses to the cues. Eye tracking was not used; instead, head orientation served as a proxy for alignment, consistent with participant reports and prior work [52, 55]. Following Gamer and Hecht [19], we applied the cone of gaze (8.12°) to the 1.5m scene distance, resulting in a 21 cm width (Figure 2). The vertical extent matched the height of the interviewer's face. Only the EYES cue was positioned within this cone. HALO and FRAME were located outside this area. One participant was excluded due to a recording error. We logged each frame (72 Hz) and recorded whether the head ray fell within the defined cone. This technical approximation differs from perceptual cone of gaze models [6]. For each condition, we calculated mean time spent within the cone and differences relative to NONE using confidence intervals.

Questions on Attention. Attention was assessed using two Likert-scale questions on perceived attentiveness and confidence in interpretation. The confidence item was reverse-coded to avoid acquiescence bias. Differences between conditions were evaluated using confidence intervals.

Qualitative Statements. We included three open-ended questions to gather information on participant experience, cue preference, and potential use cases. Responses were analyzed through deductive thematic analysis [8], aligned with study questions, and coded into themes. Frequency of mention served as a descriptive indication but did not determine analytical relevance.

4.6 Apparatus

The VR environment was created with Unity (version 2022.1.10) and featured a simple office with a desk positioned 1.5 meters from the interviewer's avatar, which was sourced from Mixamo[2]. Participants interacted with the environment using an HTC Vive Pro Eye headset. To accommodate individual preferences, the brightness and contrast of the scene could be adjusted.

[2]Mixamo: https://www.mixamo.com/

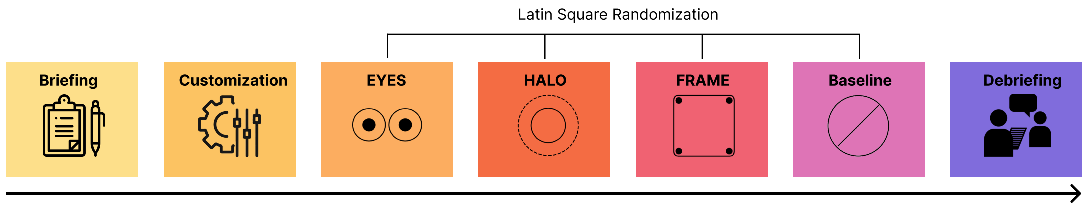

Figure 4: Study procedure. Each session lasted 60–90 minutes and followed four phases: (1) Briefing (consent, study goals, headset fitting), (2) Customization of the visual cues (*EYES, HALO, FRAME*, and *Baseline*) with user-defined parameters (size, color, opacity), (3) Experimental Blocks consisting of four sets of pre-scripted interview questions presented in counterbalanced order using a Latin square design, and (4) Debriefing with post-condition questionnaires, qualitative feedback, and final evaluation.

5 Results

We first report the analysis of head orientation data, specifically how long participants remained within the cone of gaze across the different cue conditions. This is followed by the evaluation of the two attention questions on perceived and interpreted attention, and by correlations between time in the cone of gaze and perceived attention. Finally, we summarize qualitative statements from participants, which offer more personal insights into their experiences with each cue condition.

5.1 Head Orientation

Figure 5 reports the mean time spent within the cone of gaze for all conditions. EYES showed the longest alignment time (M = 75.73 s, 95% CI [32.82, 129.00]), followed by HALO (M = 64.45 s, 95% CI [27.18, 107.54]) and FRAME (M = 55.91 s, 95% CI [24.73, 91.18]), with NONE lowest (M = 45.27 s, 95% CI [9.18, 88.99]). The width of the confidence intervals indicates substantial variability, with EYES showing the widest range.

We then compared each cue to NONE. EYES and HALO showed higher alignment times, but the 95% confidence intervals for the mean differences all overlapped zero, indicating no consistent effect across participants.

5.2 Questions on Attention

As shown in Figure 6, HALO and EYES received the highest ratings for both perceived and interpreted attention, whereas FRAME and NONE were rated lower and more variably. For perceived attention, HALO showed the highest mean rating (M = 4.33, 95% CI [4.02, 4.65]), followed by EYES (M = 3.92, 95% CI [3.59, 4.24]); FRAME and NONE were lower and more variable (FRAME: M = 3.33, 95% CI [2.84, 3.83]; NONE: M = 3.33, 95% CI [2.77, 3.90]). The 95% confidence intervals for HALO and EYES did not include zero in the mean-difference plots, while the interval for FRAME did. For interpreted attention, HALO (M = 4.00, 95% CI [3.46, 4.54]) and EYES (M = 3.75, 95% CI [3.14, 4.36]) again showed higher means than FRAME (M = 3.58, 95% CI [2.89, 4.27]) and NONE (M = 3.58, 95% CI [2.80, 4.37]), but here all confidence intervals for the mean differences included zero, indicating considerable uncertainty about differences between conditions.

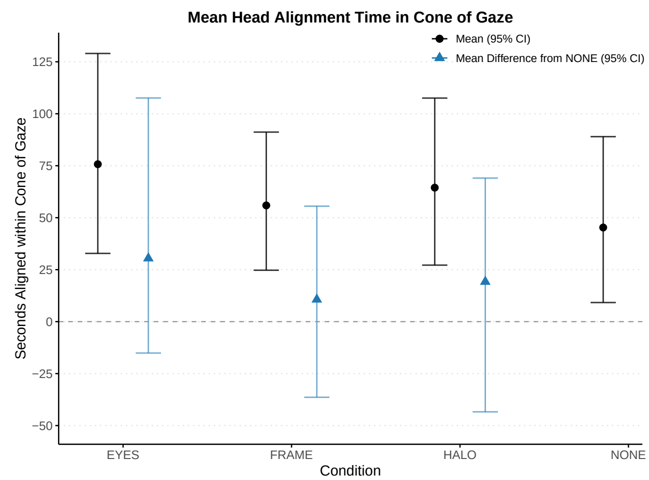

Figure 5: Mean time spent within the cone of gaze across conditions and differences vs. NONE with 95% confidence intervals.

5.3 Correlation Between Head Alignment and Perceived Attention

Figure 7 shows the Spearman correlation between alignment time and perceived attention. We focused on EYES, HALO, and NONE, as only these conditions showed differences from the baseline in the perceived attention ratings. EYES showed a moderate positive correlation (ρ = 0.63, 95% CI [0.20, 0.91]), indicating that longer alignment was associated with higher perceived attention. HALO showed a moderate negative correlation (ρ = −0.58, 95% CI [-0.92, -0.06]) despite generally high ratings, which is likely driven by compressed scores at the top of the scale (ceiling effect) rather than a reduction in perceived attention. In contrast, NONE showed no clear association (ρ = 0.03, 95% CI [-0.62, 0.63]).

5.4 Qualitative Statements

5.4.1 EYES. Three participants preferred the EYES cue (PStudy-1, PStudy-4, PStudy-9). It was described as helpful and recognizable by seven participants (PInt-1, PStudy-1, PStudy-2, PStudy-3, PStudy-4, PStudy-7, PStudy-8), primarily due to its central placement. Participants reported being guided toward the interviewer's face and showing increased orientation during the conversation. Some also

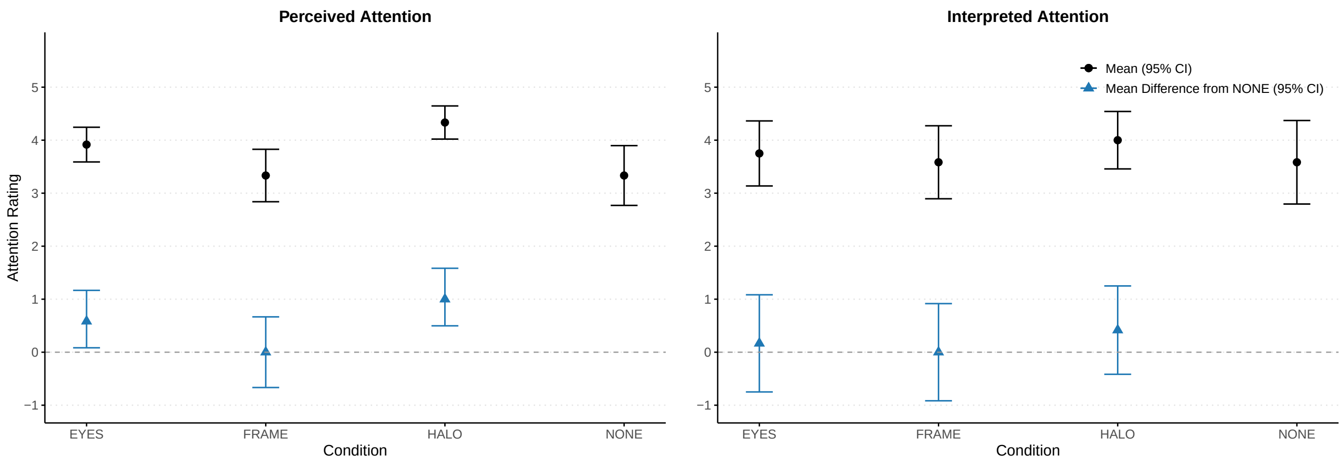

Figure 6: The figure shows the average ratings for perceived and interpreted attention. Left: average ratings for the four conditions, including 95% confidence intervals and mean differences compared to the NONE condition for perceived attention. Right: average ratings for the four conditions, including 95% confidence intervals and mean differences compared to the NONE condition for interpreted attention.

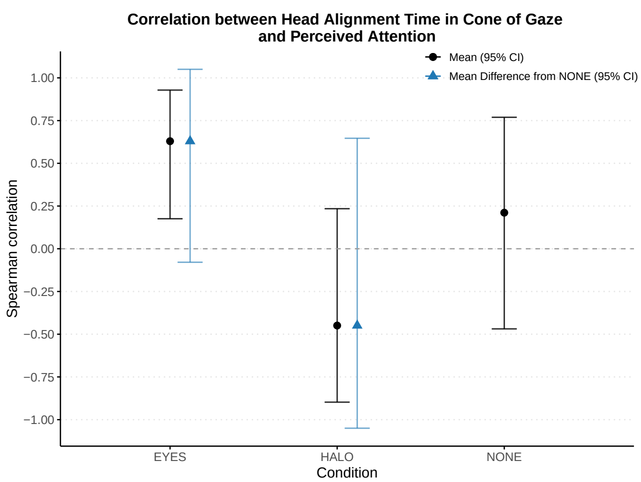

Figure 7: Spearman correlation between alignment time and perceived attention for EYES, HALO, and NONE, with mean differences to NONE (95% CI).

described the cue as familiar or reminiscent of prior visual experience (e.g., PStudy-4).

However, five participants (PStudy-1, PStudy-3, PStudy-6, PStudy-7, PStudy-11) reported distraction due to the flashing behavior, particularly at the beginning of the interview task. Two of them (PStudy-1, PStudy-11) noted that the flashing occasionally disrupted concentration. Overall, EYES offered clear guidance, but its flashing led to attentional disruption for some participants.

5.4.2 HALO. This was the most preferred cue, selected by eight participants (PInt-1, PStudy-2, PStudy-3, PStudy-6, PStudy-7, PStudy-8, PStudy-10, PStudy-11). Six participants (PInt-1, PStudy-1, PStudy-2, PStudy-3, PStudy-4, PStudy-11) reported that HALO was easy to detect and effective in guiding visual attention. Participants described it as centered, clear, and comfortable compared to the other cues. PStudy-2 also appreciated the timing of its appearance relative to gaze shifts.

Similar to EYES, some participants found the flashing cue distracting (PStudy-1, PStudy-9), although it was generally perceived as natural and easy to interpret. Overall, participants reported HALO as the most useful and visually compatible cue during the interview task.

5.4.3 FRAME. This cue received the most critical feedback and was preferred by only one participant (PStudy-5), who had central vision loss and considered the peripheral placement aligned with her perceptual strategy. For her, FRAME was less intrusive and easier to detect than centrally placed cues.

Most participants found FRAME distracting. Four participants (PStudy-1, PStudy-2, PStudy-7, PStudy-11) reported that it shifted attention away from the interviewer and toward the visual border. Two additional participants (PStudy-4, PStudy-6) described the blinking as irritating. These responses suggest that FRAME may support specific visual profiles, but is not broadly suitable for all users.

5.4.4 Usage. Nine participants stated they would use their preferred cue in a job interview (PInt-1, PStudy-1, PStudy-2, PStudy-3, PStudy-4, PStudy-6, PStudy-7, PStudy-8, PStudy-11). Participants described potential benefits for maintaining attention, detecting gaze drift, and facilitating connection with the interviewer. Some envisioned usage beyond interviews, including everyday conversations, group discussions, salary negotiations, and dating scenarios.

One participant (PStudy-5) preferred relying on auditory cues, noting that visual cues were distracting for her. Overall, most participants saw value in using cues for attention support, while emphasizing the need for flexibility across contexts and visual profiles.

6 Discussion

This work extends research on accessible gaze by examining it in evaluative settings such as job interviews. Building on prior work that documented reliance on head orientation and other proxy cues, our interviews reveal how, in this high-stakes context, inaccessible gaze is perceived as a social and evaluative threat, resulting in asymmetry, uncertainty, and pressure to demonstrate attentiveness without feedback. In the VR evaluation, spatially anchored cues (EYES, HALO) were consistently preferred over the peripheral cue (FRAME). HALO emerged as the most favored design across visual profiles. Although quantitative effects showed variability, qualitative feedback revealed clear preferences for cues that aligned with the social source of attention. Nine participants stated they would use their preferred cue in real interviews, indicating acceptance beyond experimental settings. Our sample was small and heterogeneous, and did not systematically cover the full range of visual impairments. As a result, our findings should not be read as a universal solution, but as an exploratory characterization of how participants in this study experienced and appropriated these cues.

Three themes emerged: (1) gaze as a source of social asymmetry in interviews, (2) interpretation of cues through spatial and social context, and (3) links between visual profiles and cue preferences. Together, these findings underscore that accessible gaze design must strike a balance between perceptual access and social appropriateness.

6.1 Social Asymmetry in Job Interview Settings

Participants described interviews as situations where visual barriers intersect with social expectations of attentiveness and engagement. Gaze was seen as essential for signaling engagement and presence, aligning with prior work on gaze as a predictor of interview performance [16, 37]. Participants described feeling at a disadvantage when they could not perceive the gaze of others, leading to one-sided interactions and reduced confidence. Some attempted to approximate eye contact, while others disengaged due to fatigue or overload. These findings are consistent with prior work showing that inaccessible gaze leaves users uncertain about how their behavior is received [22, 43, 55]. Our interviews extend this by showing that, in job interviews specifically, compensatory strategies such as orienting the head toward the speaker are experienced as effortful and incomplete: participants described them as tiring and less nuanced than visual feedback, and some linked failures of eye contact in this context to disrespect. Some participants reported internalizing societal expectations that link eye contact with competence, reflecting ableist norms. Our cues were intended to reduce exclusion but might also reinforce these expectations, so we offered them as an optional aid instead of a requirement for how to look. At the same time, our prototype primarily supports candidates, not interviewers. This reflects a broader tension in assistive technologies: tools that help people with disabilities meet existing norms can also shift the burden of adaptation almost entirely onto them, instead of questioning those norms or supporting interviewers to behave more inclusively.

6.2 Participants Interpreted Cues Through Spatial and Social Context

Participants evaluated cues not only by detectability but also by how they fit interactional norms. EYES and HALO aligned with familiar attentional sources, and some participants associated them with earlier visual experiences (e.g., PStudy-4). HALO was often described as intuitive and socially comfortable, while FRAME was rejected for drawing focus away from the interviewer. These findings parallel work on PeopleLens [27], which has shown that technically accurate cues may still disrupt interactions if they do not align with social expectations. Our results indicate that accessibility requires both perceptual access and social fit, especially in evaluative contexts.

6.3 Visual Profiles and Cue Preferences

Patterns emerged when considering visual profiles. Participants with central vision loss generally preferred centrally anchored cues such as HALO or EYES, citing clarity and alignment with the conversational partner. FRAME was mostly rejected, as its fixed peripheral position decoupled it from the interviewer. Only one participant preferred FRAME, noting that it matched her perceptual strategy. Some participants with central vision loss still preferred EYES, suggesting that perceived social appropriateness may outweigh purely perceptual considerations.

Physical alignment did not always correspond with perceived attention. The correlation analysis showed heterogeneous effects with wide confidence intervals. In NONE, correlations were near zero, indicating that alignment alone did not increase perceived attention. With EYES, a moderate positive correlation emerged. HALO showed a negative correlation due to ceiling effects [11], with high ratings compressed at the top of the scale. These patterns suggest that cue interpretation may rely on distinct perceptual and social processes.

Overall, tailoring cues to visual profiles is essential, but it is also insufficient. Participants emphasized the importance of flexible, customizable designs and noted that social fit influenced their acceptance. Accessible gaze design must balance three dimensions: perceptual detectability, social appropriateness, and user agency. EYES and HALO supported awareness of attentional focus but were most valued when they helped participants navigate the asymmetry of interviews. Accessibility involves making information available and socially meaningful.

6.4 Design Considerations for Visual Gaze Cues

Our findings refine prior guidelines on accessible gaze by identifying four design considerations that become particularly salient in formal, high-stakes interactions such as job interviews: adaptability to diverse visual profiles, contextual fit, spatial and temporal congruence, and users' expressive interpretations of the cues.

Adaptability. Cues must be adaptable to individual visual abilities. Participants showed diverse preferences for cue size, color, opacity, and placement, reflecting differences in acuity, contrast sensitivity, and visual field loss. Providing fine-grained control over these parameters enables users to maximize visibility or minimize glare and distraction according to their needs.

Contextual Fit. Cue design should align with the norms and expectations of the intended social context. In job interviews, participants valued cues that felt natural and unobtrusive, avoiding overly conspicuous designs that could be perceived as distracting or socially inappropriate. At the same time, gaze-augmentation cues must be designed and used in ways that do not encourage users to fixate them rigidly; a prolonged, unwavering focus on a HALO marker around the interviewer's head could easily be read as a robotic or socially awkward stare rather than as natural engagement. This context sensitivity may differ in informal or peer-to-peer interactions. Moreover, our findings reflect cultural contexts where direct eye contact signals competence and attention. In cultures with different gaze norms, these cues may require fundamental redesign or could be counterproductive [21]. Future implementations must account for cultural diversity in professional settings.

Congruence in Space and Time. Cues positioned near the source of gaze (e.g., the eyes or head) were easier to interpret as attentional signals than those anchored elsewhere. Spatial alignment with the social target appeared to support intuitive orientation, while temporal smoothness, avoiding abrupt flashing, helps maintain focus and prevents distraction.

Expressive Interpretation. In our study, cues encoded a simple binary state (visible vs. hidden), and several participants commented on the rhythm and "flashing" of the cues as distracting or hard to interpret. This suggests that users may implicitly attribute more nuanced, expressive meanings to these changes over time. Designing cues that represent socially meaningful states (e.g., sustained vs. shifting attention) rather than only discrete on/off events may therefore help reduce rapid signal changes and better match participants' interpretations.

Taken together, these considerations suggest that designing effective gaze cues requires a careful balance of personalization, spatial logic, contextual appropriateness, and interoperability. While our study focused on making gaze visually accessible, our interviews and user study underline that gaze is not just a signal but part of a social performance. Designing assistive systems in this space means balancing clarity with subtlety and assistance with intrusion; visibility alone does not create understanding, as assistive technologies are embedded in functional, social, and cultural layers of experience [17]. What mattered to participants was not simply what the cue showed, but whether it felt natural in the interaction and supported a sense of connection, suggesting that systems should support user agency rather than training users to perform normative eye contact.

6.5 Limitations & Future Work

This work was designed as an exploratory study with 20 participants (8 interviews and 12 user studies), which limits the generalizability of the quantitative findings. We therefore focused on indicative trends and qualitative patterns across diverse visual profiles and strategies. While the controlled VR environment provided a consistent and socially meaningful setting, it cannot fully capture the dynamics of real job interviews. Technical factors such as tracking and latency, as well as interpersonal aspects like emotional nuance, gestures, or gaze aversion, were simplified. Our simulation relied on literature-informed timing for speaking and listening phases, but did not replicate the full complexity of natural conversations between sighted and people with visual impairments [28].

These constraints underline the need for more ecologically valid in-situ studies to examine how gaze cues integrate into authentic routines over time.

Further, we did not measure downstream performance outcomes, such as interviewer ratings, recall of content, or hiring decisions, so we cannot claim that the cues improve interview success. Our findings are limited to subjective experience and head-alignment behavior and should be understood as characterising real-time conversational support rather than as demonstrating performance gains.

Another limitation concerns cultural specificity. The study was conducted in two countries where direct eye contact is strongly associated with attentiveness and confidence. As gaze norms vary across cultures [1, 50], our findings may not transfer directly to contexts where gaze carries different social meanings. Ensuring that gaze cues are both accessible and socially appropriate, therefore, requires careful consideration of cultural diversity.

Beyond these limitations, our work opens several directions for future research. We focused exclusively on visual representations of gaze to examine spatial placement and perceptual access. It remains an open question how visual cues compare to tactile or auditory alternatives, or how these modalities might be effectively combined. Prior work has explored non-visual representations such as auditory icons, spatialized sound, and vibrotactile feedback [12, 29, 41, 44, 54], each offering unique advantages and trade-offs. Future research could build on these efforts to develop multimodal systems tailored to users' sensory profiles and preferences.

Finally, while VR enabled us to prototype and evaluate cues in a controlled setting, the ecological validity of our findings remains limited. The next step is to investigate how gaze cues function in real-world job interviews and everyday professional interactions. AR systems could play a role here by overlaying indicators into physical environments, but challenges such as tracking accuracy, latency, and occlusion handling must first be addressed, particularly in dynamic or crowded spaces.

Together, these directions underscore the importance of moving beyond controlled VR experiments toward culturally sensitive, multimodal, and ecologically valid systems that can provide meaningful support to people with visual impairment in diverse social and professional contexts.

7 Conclusion

We designed three distinct visual cues to augment gaze during job interviews, based on related research and a formative study. In our VR evaluation with 12 people with visual impairments, spatially anchored cues placed around the interviewer's eyes or head were perceived as most helpful, supporting orientation toward the conversational partner and a clearer sense of attentional focus. Overall, our findings suggest that the cues influenced participants' sense of being attended to more than their actual head alignment. Preferences and interpretations of the cues varied with users' visual profiles and strategies: visibility alone was not sufficient, as participants valued cues that felt socially plausible and emotionally appropriate under interview pressure and that helped them time responses and signal engagement. Visibility alone was not sufficient; users responded to whether the cues felt socially plausible, emotionally appropriate, and usable under pressure. Participants described the cues not just as perceptual aids, but as tools for timing responses, showing engagement, and regaining a sense of connection.

While our implementation was limited to a controlled VR environment, the underlying principles can inform early AR prototypes that augment face-to-face interviews with subtle gaze indicators, but they will need to be validated in real offices with variable lighting and visual clutter. Our work contributes not only to accessible interaction designs but also to broader efforts to reduce asymmetry and promote inclusion in evaluative and socially demanding settings, such as job interviews.

Acknowledgments

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