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Gaze Strategies in Virtual Idol Livestreams and Their Influence on Online Interaction Through Social Presence and Trust

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Abstract

With the growing commercial prominence of virtual idol livestreaming, this study examines how gaze strategies employed by virtual idols in livestreaming contexts are associated with viewers' online interaction intention and tests the mediating roles of social presence and trust. Drawing on the SOR model, this study conceptualizes gaze strategies through a two-layer stimulus structure that integrates virtual idol behavioral cues and viewers' perceptual responses. A 3 × 3 experimental design was employed, manipulating gaze intensity and gaze dynamics at the behavioral layer using virtual idol livestream clips as stimuli, while participants' perceived gaze was treated as a stimulus variable at the perceptual layer. Data from 398 participants were analyzed using partial least squares structural equation modelling and multivariate analysis of variance. Results indicate that gaze intensity is positively associated with perceived gaze, which in turn is linked to higher levels of social presence and trust. By contrast, the overall effect of gaze dynamics appears more limited, although high-dynamics conditions are associated with lower levels of trust and online interaction intention. The structural model provides evidence that gaze strategies are indirectly associated with online interaction intention through the mediating roles of social presence and trust. The contributions of this study are twofold. First, it provides an empirical basis for subsequent research on virtual character behavior in livestreaming contexts. Second, it offers context-specific insight into a potential pathway through which gaze-related cues may be associated with online interaction intention.

Keywords: gaze behavior; virtual idols; social presence; trust; livestreaming; online interaction

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1. Introduction

Virtual idols have evolved from subcultural phenomena to mainstream commercial applications [1]. Supported by technologies such as motion capture, artificial intelligence, and virtual reality, their capabilities have advanced considerably [2]. Virtual idols now engage with fans in real time through livestreaming, a format that has gained global popularity and substantial commercial success [3]. For instance, Kakao Entertainment's virtual idol audition program Girls Rebirth attracted over one million views within three days [4]. Similarly, the virtual group A-SOUL, developed jointly by ByteDance and Yuehua Entertainment, generated more than 100 million RMB in a single livestreaming session [5]. Livestreaming has become a key media form through which virtual idols achieve commercial participation and value conversion.

Compared with traditional celebrities and human streamers, virtual idols resonate strongly with Generation Z and exert significant influence on their purchasing behavior [6]. Virtual idol fans constitute 63.6% of all fandom groups, with 37.6% of respondents indicating willingness to invest more than they would in human idols [7]. As conceptual entities co-created by production companies and fans, virtual idols allow greater fan involvement in creative processes [8]. Moreover, perceived as flawless in both appearance and morality and immune to real-world scandals, they enable unconstrained projection of fan expectations [9]. However, lacking a physical body, virtual idols depend exclusively on non-physical interaction, with online engagement serving as the primary channel of communication [10]. Through this channel, they fulfil social needs, offer emotional support, and mitigate stress and self-esteem concerns [11]. Consequently, online interaction constitutes the core mechanism for sustaining user relationships.

Eye contact represents a fundamental nonverbal cue, as individuals typically require the perception that their conversational partner is looking at them [12]. Gaze serves as a primary trigger for social interaction [13]. In mediated settings, direct camera gaze elicits a sensation of being looked at, fostering reciprocity, intimacy, and heightened parasocial engagement [14]. This principle is likewise applicable to virtual characters, whereby realistic gaze behavior prompts viewers to perceive them as possessing perceptual awareness [15]. As with human celebrities, admiration and consumption of virtual idols depend heavily on parasocial interaction [5,6]. Although gaze constitutes a vital communicative tool for virtual idols, existing research has yet to examine their gaze strategies systematically.

In virtual environments, individuals experience greater social presence when interaction appears sufficiently realistic [15], and higher social presence causes users' social responses to resemble those in real-world interactions. Therefore, social presence constitutes a critical determinant of effective social interaction with virtual characters. Simultaneously, people tend to trust speakers who maintain direct gaze [16]. When viewers perceive virtual idols as trustworthy, they display stronger attitudinal and behavioral responses [17]. In livestreaming contexts, research confirms that social presence and trust significantly affect users' continued participation behavior [18].

Existing research on virtual idols has primarily examined purchase intention [5,6,19] and brand endorsement [2,11,17,20]. However, research on the mechanisms through which virtual idols' behaviors in commercial livestreaming contexts elicit consumer interactive behaviors, such as online communication, paid content consumption, and virtual gift giving (tipping), remains limited. Current studies frequently treat virtual idols as communication media or consumption symbols rather than as active interactive agents, thereby lacking a systematic account of livestreaming behavioral strategy mechanisms. Accordingly, there is a need to further examine how gaze behavior functions in virtual idol livestreaming contexts, particularly in relation to users' social presence, trust, and online interaction intention. In this regard, this study aims to understand the role of gaze strategies employed by virtual idols in livestreaming contexts in shaping users' perceptions and their subsequent intention to engage in online interaction, and to assess whether and to what extent such effects occur. This study addresses the following research questions (RQs):

RQ1. To what extent are gaze strategies associated with users' social presence?

RQ2. To what extent are gaze strategies associated with users' trust?

RQ3. How are gaze strategies associated with users' online interaction intention?

RQ4. What is the relationship between users' social presence and trust?

RQ5. How do social presence and trust mediate the relationship between gaze strategies and online interaction intention?

The remainder of this paper is structured as follows. Section 2 reviews the relevant literature on virtual idols, gaze behavior, social presence, and trust. Section 3 develops the

research hypotheses and presents the conceptual model. Section 4 describes the research methodology, including stimulus design, measurement instruments, and data collection procedures. Section 5 reports the empirical results. Section 6 discusses the findings. Finally, Section 7 outlines the practical implications and directions for future research.

This study adopts the stimulus–organism–response (SOR) model as its theoretical foundation to examine the psychological processes underlying users' responses to virtual idols' confirming the equilibrium gaze strategies. The theoretical contribution of this study does not lie in proposing a new framework, but in distinguishing between behavioral gaze cues and perceived gaze as a stimulus within the SOR framework by incorporating them into the same analytical model, thereby providing a more specific description of the stimulus layer. In the context of virtual idol livestreaming, the study provides empirical evidence on the relationships among gaze-related stimuli, social presence, trust, and online interaction intention. At the practical level, the findings offer guidance for the differentiated design and livestreaming performance strategies of virtual idols, supporting content creators in optimizing presentation practices in livestreaming and operational contexts, thereby facilitating the stable and sustainable commercial operation of virtual idols.

2. Theoretical Background and Literature Review

2.1. Definition and Development of Virtual Idols

Most cultural contexts define virtual idols as digital celebrities created through computer graphics technologies [8,10,19–21], with their development closely linked to technological progress. The term "virtual idol" originally referred to bishōjo characters in games and anime [22]; the concept emerged in Japan during the 1990s [6,20], initially taking the form of hand-drawn 2D images. Subsequent improvements in 3DCG software and tools such as Apple ARKit (Apple Inc., Cupertino, CA, USA) and MetaHuman Creator (Epic Games, Cary, NC, USA) reduced the production threshold for digital humans [23], allowing virtual idols to perform and interact in real time at lower cost. Virtual YouTubers (VTubers), who livestream using 3DCG avatars, emerged in this context [24]. In 2016, Kizuna AI published her first video [25] and began conducting concerts and fan events with real-time motion capture in 2018. By 2020, VTuber monthly views surpassed 1.5 billion [26], and by 2021 they held eight of the top ten positions in YouTube's Super Chat revenue rankings [27].

In summary, livestreaming has become the dominant channel for virtual idol communication, providing interactive opportunities unavailable in traditional influencer formats [28]. Livestreaming facilitates real-time engagement through instant messaging and virtual gifts [29]. Comments and chat convey emotional expression and participation, whereas gifting represents a tangible manifestation of emotional support, expressing appreciation and recognition [30]. Beyond these interaction forms, user responses in livestreaming are also shaped by nonverbal communication cues. In livestreaming contexts, streamers' nonverbal communication—such as gaze, gestures, and posture—has been shown to be associated with users' behavior and cognition [31,32]. With advances in computer vision, motion capture, and real-time rendering technologies, nonverbal behaviors of virtual characters can now be precisely represented and measured [33]. These developments provide the methodological foundation for systematically examining nonverbal communication in virtual idol livestreaming contexts. However, existing research has largely focused on human livestreaming [31,32], while nonverbal strategies in virtual idol livestreaming remain insufficiently explored. Therefore, more systematic investigation of specific nonverbal strategies, such as gaze, in virtual idol livestreaming is needed.

2.2. Development of Gaze Behavior Research and Its Variables

The term "gaze" derives from Middle English, first recorded in 1386, and by the 1500s denoted staring or focused looking [34]. Gaze now constitutes a central construct across multiple disciplines. In behavioral experiments, Exline pioneered systematic investigation of gaze behavior, employing one-way mirrors and timing devices to measure the frequency and duration of eye contact during face-to-face interaction involving gaze [35]. Argyle and Dean incorporated gaze direction into observational measures within affiliative–conflict theory, confirming the equilibrium between gaze and interpersonal distance in regulating interaction intimacy [36], although the one-way mirror approach later faced replication concerns [37]. Kendon subsequently refined methodology by introducing video recording [38,39]. After synthesizing relevant studies, Kleinke (1986) established that gaze is associated with perceptions of liking, attractiveness, attention, competence, social skill, psychological health, credibility, and dominance, while underscoring the significance of gaze avoidance and frequency [40]. In the 1990s, Auter demonstrated that characters maintaining direct camera gaze significantly heighten viewers' perceived closeness, engagement, and program enjoyment, marking the first application of gaze research to television media [41,42]. With advances in computer technology, Bailenson manipulated virtual presenters' gaze direction and confirmed its substantial impact on social presence [43]. Gamer and Hecht later introduced the "cone of gaze," identifying an angular range of approximately 4–9° within which individuals still perceive themselves as being gazed at [44]. Hartmann and Goldhoorn (2011) advanced the field by operationalizing "mutual awareness" as a measurable psychological variable and developing an associated scale [14]. Böckler et al. (2014) incorporated direction switching as an experimental factor [45], showing that attention capture peaks when gaze shifts from averted to direct [46]. More recently, in video-call settings, Hietanen et al. (2020) found that direct gaze is associated with positive emotional responses across real interaction, two-way video, and one-way video conditions, irrespective of the counterpart's actual existence [47]. In more recent research on virtual environments, gaze has been widely adopted as a mature behavioral indicator for assessing the effectiveness and quality of social interaction [48]. In this context, eye contact primarily associated with shaping the counterpart's subjective experience, while its effects do not necessarily translate directly into changes at the behavioral level [49].

In summary, gaze research has progressed from early observations of eye-contact behavior to multifaceted investigations of perceptual and cognitive mechanisms, extending from face-to-face interaction to television, virtual reality, and video-call settings. In existing studies, gaze behavior has been differentiated into multiple types across research contexts and experimental conditions, including eye contact, mutual gaze, and gaze avoidance. The principal experimental variables employed to operationalize gaze strategies comprise temporal properties such as duration and frequency, which determine gaze persistence [35,50], and directional properties including gaze direction and direction switching, which influence attentional capture [45,51,52]. Beyond observable behavioral cues, prior research has shown that the perception of "being looked at" constitutes a distinct perceptual outcome [53]. Multiple external cues (e.g., gaze direction and head orientation) jointly influence individuals' perception of whether they are being looked at, resulting in potential discrepancies between objective gaze behavior and perceived gaze. Specifically, objective gaze direction does not directly correspond to individuals' perception of gaze direction [54]. Signal detection theory further indicates that the presence of an external signal does not necessarily correspond to its subjective detection [55,56]. Whether individuals subjectively perceive being looked at is associated with subsequent psychological responses, and such perception constitutes an important precondition for the emergence of gaze effects [57]. Moreover, in social communication, individuals' egocentric perspective

can bias their subjective experience and judgment of stimuli [58]. Therefore, analyses based solely on the behavioral level of gaze may overlook the perceptual process, thereby leading to potential misinterpretation of gaze effects. It should be noted that, although perceived gaze reflects a subjective perceptual outcome, its functional role within the SOR framework requires further clarification. According to Brunswik's lens model, individuals do not directly access external objects but instead rely on proximal cues to make judgments about the environment [59]. At the same time, gaze processing follows a two-stage mechanism, in which low-level visual cues first capture attention, followed by higher-order cognitive processing [60]. On this basis, perceived gaze can be understood as a proximal cue derived from external gaze-related stimuli. In mediated contexts, when a character looks directly into the camera, viewers automatically develop the feeling that the character is looking at them personally [57]. Taken together, these findings suggest that perceived gaze represents the immediate perceptual outcome of external gaze cues. Its function is to transform objective behavioral signals into perceptually accessible input, thereby triggering subsequent psychological responses. From a methodological perspective, prior SOR-based research indicates that the positioning of variables within the stimulus layer may vary depending on the research context. In some studies, perceptual or interpretative constructs have been operationalized as stimulus variables to capture individuals' perceived environmental inputs [61]. For example, perceived organizational characteristics such as environmental corporate social responsibility have also been modeled within the stimulus layer [62]. These precedents suggest that when a construct functions as an input signal that triggers subsequent psychological responses, positioning it within the stimulus layer is methodologically justifiable. Accordingly, stimuli in gaze experiments can be analytically distinguished into behavioral-level and perceptual-level layers, which can be integrated within a unified framework (see Table 1). To systematically examine the mechanisms of gaze effects, the present study adopts both stimulus layers in the subsequent experimental design.

Table 1. Gaze stimulus dimensions and variable definitions.

Stimulus Dimension	Variable Name	Definition
Behavioral Layer	Gaze Intensity	The proportion of time during which the stimulus maintains eye contact with the viewer within a given time interval
Behavioral Layer	Gaze Dynamics	The number of times the stimulus switches gaze direction within a given time interval
Perceptual Layer	Perceived Gaze	The intensity of being gazed at as subjectively perceived by participants in the survey

In the context of virtual idol livestreaming, given that virtual idol fandom and consumption rely on parasocial interaction [5,6], and that parasocial interaction is influenced by the perception of being looked at [57], this study does not treat perceived gaze as directly equivalent to external stimuli. Instead, gaze strategies are distinguished into behavioral and perceived levels, and the transformation process from behavioral presentation to perceptual experience is incorporated into a unified analytical framework to capture relatively complex gaze stimuli.

2.3. Social Presence and Trust

Social presence denotes "the sense of being with another" [63] (p. 456). Short et al. (1976) originally conceptualized it [64], identifying intimacy and immediacy as core components shaped by both verbal and nonverbal cues [65]. Early studies focused on medium characteristics, whereas Social Information Processing Theory posits that individuals adapt

to available channels, implying that social presence depends primarily on interactants' perceptions. Both perspectives underscore that media technologies and communication strategies substantially shape social presence [66]. Regarding measurement, Biocca (2001) developed the Networked Minds Social Presence Inventory (NMSPI), encompassing co-presence, psychological involvement, and behavioral engagement [67]. Hassanein and Head (2007) adapted this framework to e-commerce, demonstrating that socially rich interfaces enhance trust and affective responses [68]. In game-streaming environments, Lim et al. (2020) conceptualized social presence as emotional co-presence among viewers, streamers, and other participants [69]; Lv et al. (2022) subsequently refined prior frameworks to devise a social presence scale tailored to livestreaming interaction, retaining co-presence and psychological involvement as central dimensions [18].

Trust is defined variably across contexts [70]. In general terms, it represents confidence in another party's favorable conduct [71]. Within online livestreaming, trust manifests as perceived safety and willingness to depend on the streamer or content [18]. Early measurement approaches drew from e-commerce and institutional assurance paradigms [71,72] before extending to interpersonal dynamics in virtual communities. Hsu et al. (2007) broadened the construct beyond transactions, proposing economy-based, information-based, and identification-based dimensions [73]. Chu and Kim (2011) situated trust within social networking services to assess perceived credibility and reliability of connections [74]; Lv et al. (2022) subsequently adapted established scales to livestreaming contexts, measuring viewers' trust in streamers and content [18].

Online interaction refers to viewers' real-time participatory behaviors during livestreaming, which can reduce the social distance between viewers and streamers as well as among viewers themselves [18]. Early forms of online interaction were primarily limited to real-time text-based communication between the streamer and the audience or among viewers [75]. Subsequently, online interaction expanded to include livestream commerce behaviors, such as purchasing products recommended by streamers during broadcasts [76], as well as virtual gift-giving behaviors directed toward streamers [75]. Building on these interaction types, Lv et al. (2022) and Liu et al. (2025) developed measurement scales that integrate multiple forms of online interactive engagement in livestreaming contexts [18,77].

3. Research Model and Hypotheses

Based on the stimulus–organism–response (SOR) framework, this study conceptualizes virtual idols' gaze strategies as stimulus-related factors. Specifically, gaze intensity and gaze dynamics are treated as behavioral-level stimuli that are experimentally manipulated, while perceived gaze serves as the effective stimulus within the SOR process, reflecting individuals' subjective perception of these external gaze cues. Social presence and trust are positioned as organism variables (O), and online interaction intention as the response (R). Within this framework, perceived gaze is expected to be associated with users' internal psychological states, which in turn shape their behavioral intentions.

Within this framework, prior research suggests that social presence emerges from social cues [63,64]. In video-mediated communication, eye contact substantially shapes perceptions of the interlocutor's presence [12]; when individuals perceive themselves as being gazed at, they tend to display responses comparable to those in face-to-face encounters [47]. In virtual settings devoid of physical co-presence, gaze elicits perceived gaze, which subsequently prompts attributions of presence to the virtual agent [43,78]. Experimental evidence further demonstrates that mutual gaze from virtual characters significantly heightens social presence [15].

Therefore, in the context of virtual idol livestreaming, perceived gaze may be associated with enhanced social presence, as it reflects the extent to which viewers experience being attended to by the virtual idol. Accordingly, the following hypothesis is proposed:

H1. Perceived gaze is positively associated with viewers' social presence.

Building on the SOR framework, gaze also functions as a key social signal in the formation of trust. Prior research indicates that gaze is associated with higher levels of perceived likability and engagement and serves as a primary cue for trust formation [79]. Extensive research confirms that speakers who sustain eye contact are judged as more honest and trustworthy across diverse contexts, including physician–patient interaction, human–computer interaction, and parasocial relationships [16]. In human–computer interaction studies, gaze proportion reliably predicts trust ratings [80,81]. In video-mediated settings, the availability of eye contact likewise is associated with trust in the communication partner [12].

Thus, in virtual idol livestreaming contexts, perceived gaze may be associated with viewers' trust evaluations, as it reflects the extent to which viewers experience direct attention from the virtual idol. Accordingly, the following hypothesis is proposed:

H2. Perceived gaze is positively associated with viewers' trust.

Within the SOR framework, social presence is further considered an important antecedent of trust. Prior studies show that social presence is positively associated with trust in online commercial transactions [68,82] and higher levels of trust toward information sources in news consumption [16]. Social presence is widely recognized as an essential antecedent of trust, a relationship that persists in interactions with virtual entities [78].

Therefore, higher levels of social presence are expected to be associated with higher levels of trust in virtual idol contexts. Accordingly, the following hypothesis is proposed:

H3. Social presence is positively associated with trust.

Within the SOR framework, organism variables are further expected to shape behavioral responses. Prior research indicates that higher social presence strengthens consumer attitudes in online consumption environments [68]. In online social contexts, social presence exerts a significant positive effect on behavioral intention, increasing users' propensity for social sharing and purchasing [83], while also fostering perceived warmth and enhancing participation in online communities [84]. In livestreaming environments, social presence generated by virtual idol streams promotes participation intention more effectively than that elicited by human streamers [18].

Similarly, trust has been shown to be associated with behavioral responses. Trust is associated with search and purchase behavior in e-commerce [71], and in online social interaction, greater trust is associated with greater willingness to rely on others, thereby being linked to higher levels of interaction likelihood [74]. In virtual idol livestreaming, trust likewise is associated with participation behaviors [18].

Taken together, social presence and trust are expected to be associated with viewers' online interaction intention. Accordingly, the following hypotheses are proposed:

H4. Social presence is positively associated with viewers' online interaction intention.

H5. Trust is positively associated with viewers' online interaction intention.

Furthermore, integrating the SOR framework, perceived gaze is expected to be indirectly associated with behavioral intention through the sequential effects of social presence and trust. Accordingly, the following hypothesis is proposed:

H6. Perceived gaze is indirectly associated with viewers' online interaction intention through the dual mediation of social presence and trust.

Taken together, the proposed hypotheses delineate a structured pathway model, and the hypothesized relationships among variables are illustrated in Figure 1.

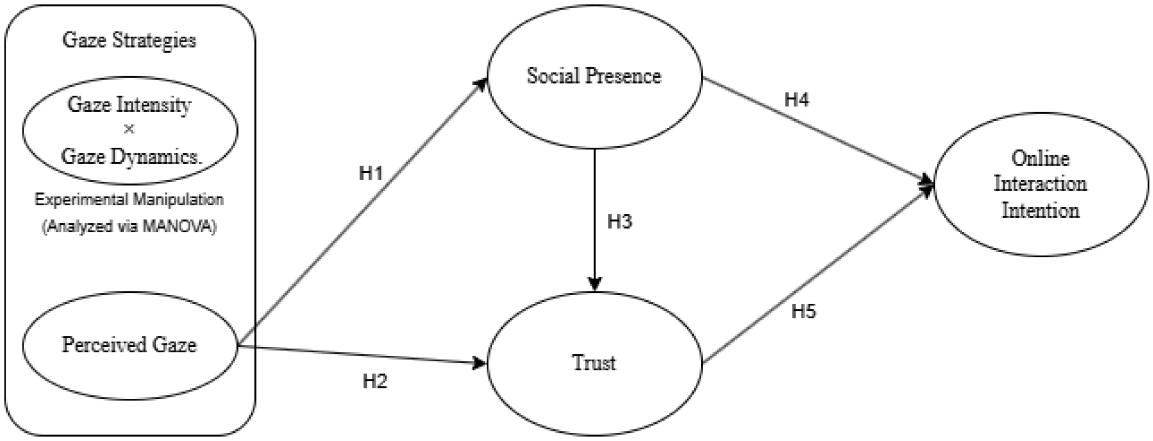


Figure 1. Research model.

4. Research Methodology

4.1. Research Procedure

This study employs a structural model-based experimental design grounded in the SOR framework. First, experimental stimuli were constructed by manipulating gaze intensity and gaze dynamics as behavioral-level stimuli. Subsequently, a questionnaire-based survey was conducted to collect participants' responses to the stimuli, including perceived gaze, social presence, trust, and online interaction intention.

For data analysis, a two-stage analytical approach was adopted. Gaze intensity and gaze dynamics, as experimentally manipulated behavioral variables, were analyzed using multivariate analysis of variance (MANOVA) to examine differences in perceived gaze, social presence, trust, and online interaction intention across experimental conditions. In parallel, perceived gaze was treated as the effective stimulus within the SOR process and was analyzed using partial least squares structural equation modelling (PLS-SEM) to assess the measurement model and evaluate the structural relationships among perceived gaze, social presence, trust, and online interaction intention.

4.2. Experimental Stimulus Design

Based on prior gaze research, this study separates the stimulus component of the experimental model into a behavioral layer and a perceptual layer. At the behavioral layer, stimulus clips were constructed by manipulating gaze intensity and gaze dynamics. Gaze intensity was operationalized using the gaze ratio method proposed by Argyle and Dean (1965) [36], classifying the proportion of direct gaze within each livestream clip as high (67–100% ≈ 10–15 s), medium (34–66% ≈ 5–10 s), or low (0–33% ≈ 0–5 s). Gaze dynamics was defined with reference to the "comfortable duration" of single gaze episodes reported by Binetti et al. (2016; approximately 2.9–4.6 s) [85] and categorized according to switching frequency as low (>5 s), medium (3–5 s), or high (<3 s), resulting in a 3 × 3 experimental design. To maintain participants' attention while controlling stimulus duration, all clips were standardized to 15 s, following short-exposure units commonly adopted in media research to elicit cognitive and attentional processing while sustaining a relatively focused attentional state [86]. Materials were drawn from livestream recordings of the virtual idol Kizuna AI. Framing, lighting, and duration were held constant across conditions to ensure the independence of manipulated variables.

4.3. Technical Processing of Stimuli

To operationalize gaze-related variables, OpenFace 2.0 (Carnegie Mellon University, Pittsburgh, PA, USA) was used to detect facial landmarks and gaze vectors on a frame-by-

frame basis (see Figure 2). Based on the effective gaze angle criterion (direct gaze defined within ±9°) [53], gaze_angle_x and gaze_angle_y were employed to compute frame-level gaze deviations in order to identify direct gaze frames.

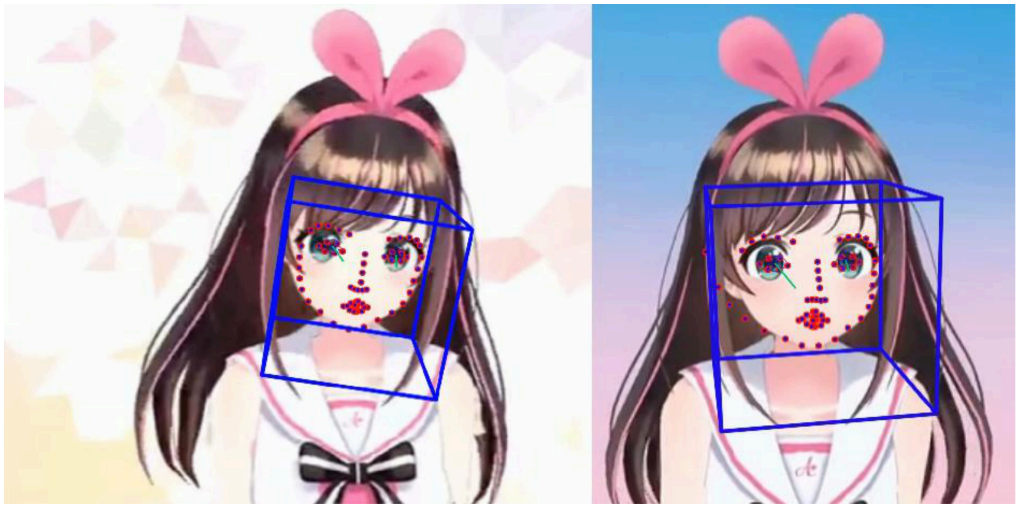


Figure 2. Illustration of OpenFace detection.

To ensure the continuity of facial feature extraction and the stability of algorithmic tracking, all OpenFace data were extracted from the original continuous video streams. This is because OpenFace's tracking mechanism—based on convolutional neural networks and constrained local models—relies on temporal context from preceding frames for initialization and calibration [87]. Extracting data from continuous video streams helps minimize recognition errors caused by missing key frames or failed initial calibration.

To ensure measurement validity, only video segments containing frames with success = 1 and confidence values exceeding the threshold of 0.7 were retained. Using the resulting detection data, gaze_angle_x and gaze_angle_y were employed to compute frame-level gaze deviations in order to identify direct gaze frames. The proportion of direct gaze frames was then calculated to classify gaze intensity. In parallel, sequences of direct gaze frames were aggregated into continuous gaze bouts, and the average duration of single bouts was computed to classify gaze dynamics.

Based on these results, boundary cases were manually reviewed to exclude abnormal segments caused by algorithmic jitter or facial detection errors, yielding the final set of experimental stimulus clips.

4.4. Measurement Instruments and Questionnaire Design

The questionnaire was designed and administered via the Chinese online survey platform www.wjx.cn and distributed on Bilibili, a leading video community for Generation Z in China and one of the most active platforms for virtual idol audiences [88].

The questionnaire consisted of five sections: demographic information, screening questions, manipulation check variables, mediator variables, and dependent variables. The demographic section was used to obtain participants' basic information. The screening questions were designed to reduce potential bias arising from pre-existing fan attachment by excluding participants who identified themselves as fans of the stimulus virtual idol. For the manipulation-check, mediator, and dependent variables, all measurement items were adapted from established and previously validated scales to ensure reliability and validity. Responses were recorded on a seven-point Likert scale (1 = strongly disagree, 7 = strongly agree). The manipulation check assessed the effectiveness of gaze intensity and gaze dynamics through perceived gaze. The mediator variables were social presence and

trust, and the dependent variable was online interaction intention. The perceived gaze scale was adapted from the "mutual awareness" dimension developed by [14], which measures the subjective perception of a performer's attention in mediated environments. Social presence items were drawn from Bailenson et al. (2001) and Lv et al. (2022): the former focuses on subjective presence toward virtual entities in immersive environments [15,18], whereas the latter captures social and emotional presence in livestreaming interactions. The trust scale was adapted from Bente et al. (2008) and Hajli et al. (2017), which respectively validate trust measurement in human–avatar interaction and provide robust indicators for online consumption contexts [78,89]. The online interaction intention items were adapted from Lv et al. (2022) and Gefen (2000), capturing real-time participation intention in livestreaming and consumption-oriented intention in e-commerce settings [18,71]. The full questionnaire items are provided in Appendix A.

4.5. Data Collection

A total of 411 responses were collected. After applying the screening criteria to exclude participants who identified themselves as fans of the stimulus virtual idol, 398 responses were retained as valid. Sample demographics are reported in Table 2. The collected data were subsequently analyzed using SmartPLS and partial least squares structural equation modelling (PLS-SEM).

Table 2. Demographic information.

Item	Option	Frequency	Percentage
Gender	Male	202	49.1
	Female	196	47.7
Age Group	Under 18	68	16.5
	18–25	149	36.3
	26–30	126	30.7
	31–40	18	4.4
	41–50	15	3.6
	51–60	12	2.9
	Above 60	10	2.4
Occupation	Company Employee	62	15.1
	Self-Employed	13	3.2
	Corporate Manager	16	3.9
	Service Industry Worker	12	2.9
	Technical Developer/Engineer	22	5.4
	Freelancer	46	11.2
	Student	227	55.2
Monthly Income	Below 3000 RMB	125	30.4
	3000–5000 RMB	201	48.9
	5001–8000 RMB	59	14.4
	Above 8000 RMB	13	3.2

The sample exhibits balanced gender distribution, with 49.1% male and 47.7% female participants. Age is concentrated primarily in the 18–25 (36.3%) and 26–30 (30.7%) brackets. Students constitute the largest occupational group (55.2%), followed by company employees (15.1%). Monthly income clusters mainly in the 3000–5000 RMB (48.9%) and below-3000 RMB (30.4%) ranges. These demographic characteristics align closely with the core virtual idol audience profile of predominantly young individuals [90,91], confirming the sample's representativeness.

4.6. Reliability and Validity Testing

Construct reliability was assessed using SmartPLS 4.0 (SmartPLS GmbH, Oststeinbek, Germany) through Cronbach's α and composite reliability (CR) for the four latent variables. Cronbach's α ranges from 0.925 to 0.956 and CR from 0.926 to 0.959, all surpassing recommended thresholds, thereby confirming high internal consistency (see Table 3). Convergent validity was evaluated via standardized factor loadings, average variance extracted (AVE), and variance inflation factors (VIF). All loadings exceed 0.70, VIF values remain below 5, and AVE values surpass 0.50, satisfying established criteria and demonstrating strong convergent validity (see Table 4).

Table 3. Reliability assessment.

Construct	Cronbach's α	CR	Reliability Assessment
Trust (TR)	0.941	0.941	Acceptable
Social Presence (SP)	0.931	0.935	Acceptable
Online Interaction Intention (OI)	0.956	0.959	Acceptable
Perceived Gaze (PG)	0.925	0.926	Acceptable

Table 4. Convergent validity assessment.

Construct	Item	Loading	VIF	AVE	Validity
PG	PG1	0.937	3.801	0.869	Acceptable
	PG2	0.931	3.552		
	PG3	0.930	3.316		
SP	SP1	0.910	3.291	0.828	Acceptable
	SP2	0.907	3.388		
	SP3	0.919	3.501		
	SP4	0.905	3.328		
TR	TR1	0.922	3.823	0.849	Acceptable
	TR2	0.926	3.949		
	TR3	0.917	3.661		
	TR4	0.920	3.798		
OI	OI1	0.922	4.285	0.851	Acceptable
	OI2	0.917	4.138		
	OI3	0.923	4.487		
	OI4	0.918	4.280		
	OI5	0.932	4.674		

Discriminant validity was examined using the Fornell–Larcker criterion and the heterotrait–monotrait (HTMT) ratio. Square roots of AVE (0.921, 0.910, 0.922, 0.932) exceed corresponding inter-construct correlations, and the HTMT values fall below the conservative threshold, indicating good discriminant validity of the constructs. The HTMT values in this study range from 0.165 to 0.474, all below the 0.90 threshold, further supporting the discriminant validity of the measurement model (see Tables 5 and 6).

Table 5. Fornell–Larcker criterion.

Construct	Trust	Social Presence	Online Interaction Intention	Perceived Gaze
TR	0.921			
SP	0.228	0.910		
OI	0.451	0.220	0.922	
PG	0.240	0.273	0.155	0.932

Table 6. HTMT assessment.

Construct	Trust	Social Presence	Online Interaction Intention	Perceived Gaze
TR	—			
SP	0.242	—		
OI	0.474	0.232	—	
PG	0.256	0.293	0.165	—

4.7. Multicollinearity and Explanatory Power Testing

Collinearity diagnostics in the structural model (see Figure 3) reveal all inner VIF values well below 5, indicating absence of multicollinearity. R^2 values reflect moderate explanatory power within the present model for the endogenous constructs. Effect size analysis (f^2) shows that trust shows the strongest association with online interaction intention ($f^2 = 0.217$), whereas most remaining paths display small effects (see Table 7). Bootstrap analysis (5000 resamples) was employed to evaluate structural path significance (Table 8). All hypothesized direct paths were found to be significant and positive, providing support for H1–H5. Trust exhibited the strongest effect on online interaction intention ($\beta = 0.423$, $p < 0.001$).

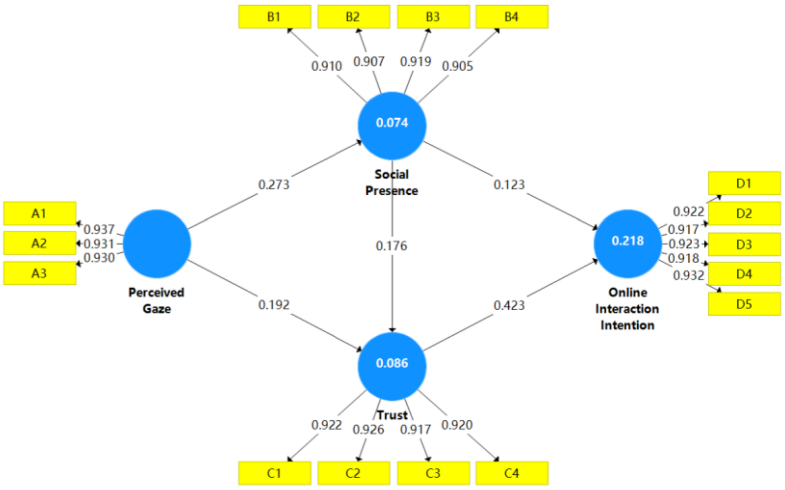


Figure 3. Structural model.

Table 7. F-square values.

Construct	f^2
TR → OI	0.217
SP → OI	0.018
SP → TR	0.031
PG → TR	0.037
PG → SP	0.080

Table 8. Path coefficients and hypothesis testing.

Path	Coefficient (β)	SE	t-Value	*p*-Value	Result
TR → OI	0.423	0.044	9.585	0.000	Supported
SP → TR	0.176	0.052	3.384	0.001	Supported
SP → OI	0.198	0.050	3.969	0.000	Supported
PG → TR	0.240	0.049	4.916	0.000	Supported
PG → SP	0.273	0.045	6.016	0.000	Supported

Further bootstrapping was conducted to test multiple mediation effects. Results showed that the indirect effects of perceived gaze on online interaction intention through social presence and trust were significant, with the 95% confidence intervals excluding zero (Table 9), providing support for H6. In addition, tests of the parallel mediation model indicated that social presence and trust each independently mediated the relationship between perceived gaze and online interaction intention. By contrast, the reverse sequential mediation path (PG → TR → SP → OI) did not reach statistical significance ($p = 0.069$), suggesting that trust did not operate as a mediator prior to social presence. Taken together, perceived gaze is associated with online interaction intention through both independent mediation paths via social presence and trust, and appears to be more strongly reflected in the sequential pathway from social presence to trust, which is consistent with the proposed model structure.

Table 9. Multiple mediation effects.

Mediation Path	Effect	SE	t-Value	*p*-Value	Result
PG → SP → TR	0.048	0.016	2.985	0.003	Supported
SP → TR → OI	0.074	0.024	3.151	0.002	Supported
PG → SP → OI	0.034	0.014	2.355	0.019	Supported
PG → TR → OI	0.081	0.023	3.520	0.000	Supported
PG → SP → TR → OI	0.020	0.007	2.829	0.005	Supported
PG → TR → SP → OI	0.005	0.003	1.817	0.069	Not supported

4.8. MANOVA and Post Hoc Analysis

Multivariate analysis of variance (MANOVA) using Pillai's Trace indicated significant main effects for both gaze intensity (V = 0.681, F = 49.959, $p < 0.001$) and gaze dynamics (V = 0.048, F = 2.389, $p = 0.015$), together with a significant interaction (V = 0.314, F = 8.290, $p < 0.001$) (Table 10).

Table 10. MANOVA results (Pillai's Trace).

Effect	Pillai's Trace	F-Value	Hypothesis df	Error df	*p*-Value
Intercept	0.971	3286.421	4	386	0.000
Gaze Intensity (GI)	0.681	49.959	8	774	0.000
Gaze Dynamics (GD)	0.048	2.389	8	774	0.015
Gaze Intensity × Gaze Dynamics (ID)	0.314	8.290	16	1556	0.000

Univariate follow-up tests showed that gaze intensity significantly associated with differences across all four dependent variables, with the largest effect on online interaction intention. Gaze dynamics significantly associated with trust, whereas the interaction term reached significance across all dependent variables (Table 11). Bonferroni post hoc comparison results are presented in Tables 12 and 13. Gaze intensity yields significant differences across all four dependent variables, displaying consistent directional patterns that form a clear gradient. For social presence, the high-intensity and medium-intensity conditions do not differ significantly ($p = 0.052$), yet both substantially exceed the low-intensity condition ($p < 0.001$). Overall, gaze intensity demonstrates stable and robust effects across all variables, with the strongest distinctions evident for trust and online interaction intention.

Table 11. Univariate ANOVA results.

Source	Dependent Variable	Sum of Squares	df	Mean Square	F-Value	*p*-Value	Partial η^2
GI	PG	109.223	2	54.611	22.439	0.000	0.103
	SP	149.302	2	74.651	38.947	0.000	0.167
	TR	400.646	2	200.323	128.463	0.000	0.398
	OI	510.940	2	255.470	179.335	0.000	0.480
GD	PG	1.162	2	0.581	0.239	0.788	0.001
	SP	4.056	2	2.028	1.058	0.348	0.005
	TR	16.431	2	8.215	5.268	0.006	0.026
	OI	7.480	2	3.740	2.625	0.074	0.013
ID	PG	25.860	4	6.465	2.656	0.033	0.027
	SP	37.479	4	9.370	4.888	0.001	0.048
	TR	63.544	4	15.886	10.187	0.000	0.095
	OI	113.814	4	28.453	19.974	0.000	0.170

Table 12. Means and standard errors by Gaze intensity and Gaze dynamics.

Dependent Variable	Condition Type	Level	Mean	Std. Error
PG	Gaze Intensity	High	5.221	0.193
		Medium	4.776	0.158
		Low	3.793	0.132
	Gaze Dynamics	High	4.533	0.132
		Medium	4.676	0.160
		Low	4.581	0.191
SP	Gaze Intensity	High	4.899	0.171
		Medium	4.677	0.140
		Low	3.366	0.117
	Gaze Dynamics	High	4.174	0.117
		Medium	4.438	0.142
		Low	4.329	0.170
TR	Gaze Intensity	High	5.469	0.154
		Medium	4.559	0.126
		Low	2.711	0.106
	Gaze Dynamics	High	4.094	0.105
		Medium	4.585	0.128
		Low	4.060	0.153
OI	Gaze Intensity	High	5.778	0.147
		Medium	4.770	0.121
		Low	2.671	0.101
	Gaze Dynamics	High	4.242	0.101
		Medium	4.332	0.123
		Low	4.646	0.146

Post hoc comparisons for gaze dynamics appear in Tables 12 and 13. No significant differences emerge among the three levels for perceived gaze or social presence ($p > 0.05$). For trust, only the low-dynamics condition significantly outperforms the high-dynamics condition ($p = 0.028$). For online interaction intention, the low-dynamics condition yields significantly higher scores than both medium- and high-dynamics conditions ($p < 0.001$), whereas medium- and high-dynamics conditions do not differ ($p = 0.999$).

These results indicate that gaze dynamics significantly associated with trust and online interaction intention but exerts no detectable effect on perceived gaze or social presence.

Table 13. Bonferroni post hoc comparisons for Gaze intensity and Gaze dynamics.

Dependent Variable	Condition	(I) Level	(J) Level	Mean Diff (I–J)	Std. Error	Sig.
PG	Intensity	High	Medium	0.60 *	0.237	0.012
		High	Low	1.40 *	0.221	0.000
		Medium	Low	0.80 *	0.176	0.000
	Dynamics	High	Medium	−0.04	0.177	0.817
		High	Low	−0.30	0.219	0.168
		Medium	Low	−0.26	0.237	0.271
SP	Intensity	High	Medium	0.41	0.210	0.052
		High	Low	1.44 *	0.196	0.000
		Medium	Low	1.03 *	0.156	0.000
	Dynamics	High	Medium	−0.11	0.157	0.477
		High	Low	−0.36	0.194	0.062
		Medium	Low	−0.25	0.210	0.232
TR	Intensity	High	Medium	1.23 *	0.189	0.000
		High	Low	2.60 *	0.177	0.000
		Medium	Low	1.36 *	0.141	0.000
	Dynamics	High	Medium	−0.26	0.142	0.072
		High	Low	−0.39 *	0.175	0.028
		Medium	Low	−0.13	0.190	0.492
OI	Intensity	High	Medium	1.41 *	0.181	0.000
		High	Low	2.83 *	0.169	0.000
		Medium	Low	1.42 *	0.135	0.000
	Dynamics	High	Medium	0.00	0.136	0.999
		High	Low	−0.82 *	0.168	0.000
		Medium	Low	−0.82 *	0.181	0.000

* $p < 0.05$.

4.9. Summary of Finding

Structural equation modelling indicates that perceived gaze is significantly associated with higher levels of social presence and trust, with trust exhibiting the strongest direct effect on online interaction intention. The dual-mediation pathway posited in H6 is supported, providing evidence that gaze-related perceptual cues are associated with behavioral intentions via social presence and trust.

MANOVA further helps clarify the relative contributions of the two gaze dimensions. Gaze intensity shows the strongest pattern of association among the predictors: all four latent variables show a linear pattern across intensity levels (PG: $\eta^2 = 0.103$; SP: $\eta^2 = 0.167$; TR: $\eta^2 = 0.398$; OI: $\eta^2 = 0.480$), with the largest effects observed for trust and online interaction intention ($\eta^2 = 0.398$ and 0.480). This pattern indicates that, in the present context, gaze intensity is associated with a relatively larger proportion of variance in online interaction intention. In contrast, gaze dynamics shows a comparatively modest overall influence. Its effect sizes on perceived gaze and social presence are negligible (PG: $\eta^2 = 0.001$; SP: $\eta^2 = 0.005$) and do not reach statistical significance, indicating that switching frequency alone is not directly associated with changes in perceived gaze or social presence. However, gaze dynamics shows a significant effect on trust (TR: $\eta^2 = 0.026$, small-to-moderate), while it does not produce a stable main effect on online interaction intention (OI: $\eta^2 = 0.013$, $p = 0.074$), suggesting that dynamics does not function as an independent primary driver.

Significant interaction effects indicate that the impact of gaze intensity depends on accompanying dynamic patterns. Interaction effects are observed across all four variables, with moderate-to-large effect sizes for trust and online interaction intention (TR: $\eta^2 = 0.095$;

OI: $\eta^2 = 0.170$) and smaller effect sizes for perceived gaze and social presence (PG: $\eta^2 = 0.027$; SP: $\eta^2 = 0.048$). These results suggest that gaze dynamics may operate primarily by modulating the magnitude of intensity-driven psychological effects rather than exerting an independent effect. Under high-intensity conditions, rapid switching is associated with lower levels of trust, whereas under medium intensity, moderate dynamics may be associated with higher levels of perceived social presence. In summary, gaze intensity appears to play a dominant role in shaping perceptions of being attended to and the experience of social presence, whereas gaze dynamics tends to modulate the perceived credibility and stability of these effects, most notably in trust evaluations.

5. Results

The results of the structural model indicate that the proposed hypotheses were generally supported. The two-layer gaze strategy structure—comprising behavioral manipulations (gaze intensity and gaze dynamics) and perceptual responses (perceived gaze)—was operationalized and examined through the analysis. At the behavioral layer, gaze intensity and gaze dynamics produced differentiated patterns, with gaze intensity showing a stronger and more consistent association across variables. At the perceptual layer, perceived gaze was significantly associated with both social presence and trust. Social presence was further positively associated with trust, and both social presence and trust were significantly associated with online interaction intention. The mediation analysis provides empirical support for a sequential pathway linking social presence and trust to online interaction intention within this two-layer stimulus structure.

In relation to RQ1 and RQ2, the results indicate that gaze strategies are associated with variations in viewers' perceived social presence and trust. At the behavioral level, gaze intensity emerged as the primary factor, with higher intensity associated with higher levels of perceived gaze, social presence, and trust. In contrast, gaze dynamics showed no significant association with social presence but demonstrated a limited association with trust.

Regarding RQ3, gaze strategies produced differentiated patterns in online interaction intention. Gaze intensity exhibited a strong positive association with interaction intention, with higher-intensity conditions consistently corresponding to higher levels of willingness to interact. By contrast, gaze dynamics showed a relatively weak association and, under high-dynamic conditions, was associated with lower interaction intention. A significant interaction effect between gaze intensity and gaze dynamics was also observed, indicating that the effect of intensity may vary depending on the level of dynamics.

Regarding RQ4 and RQ5, the results further indicate that social presence is positively associated with trust, and that both variables are associated with online interaction intention. The sequential pathway from social presence to trust, and subsequently to interaction intention, was supported in the model, whereas the reverse pathway was not supported.

Taken together, these results suggest that the proposed gaze strategy structure is associated with variations in social presence, trust, and online interaction intention under the present experimental conditions. Within this structure, gaze intensity appears to function as the primary behavioral driver, whereas gaze dynamics plays a comparatively limited and mainly moderating role.

6. Discussion

Based on the systematic examination and the results obtained, the following conclusions and discussions can be drawn.

The experimental results corroborate part of the findings reported in prior research. First, at the behavioral level, gaze intensity functions as the primary manipulation factor:

higher levels of gaze intensity are associated with higher levels of perceived gaze, which in turn are linked to higher levels of social presence and trust. These findings are consistent with previous studies suggesting that direct eye contact serves as a powerful socio-communicative signal in mediated environments [12,16,41,47,48,71,92,93]. Viewers appear to interpret sustained direct gaze from virtual idols as a form of attentional engagement.

Second, gaze intensity shows the strongest positive association with online interaction intention, with higher levels of gaze intensity consistently corresponding to greater willingness to interact. This finding aligns with prior research indicating that direct gaze is associated with higher levels of attention and engagement tendencies [16,41].

Third, structural equation modeling provides evidence for a sequential relationship between social presence and trust, supporting the proposed dual-mediation pathway through which gaze strategies are associated with interaction intention. A significant positive association is observed between social presence and trust, which is consistent with prior findings suggesting that enhanced presence may facilitate trust formation [16,68,78,82]. At the same time, perceived gaze is also associated with social presence and trust; although it represents only one of multiple influencing factors, this finding is consistent with previous research [47].

Taken together, these findings suggest that, within the controlled experimental setting of simulated livestreaming contexts, virtual idols' gaze-related cues may evoke socio-cognitive responses that share certain characteristics with those observed in mediated human interaction. When viewers perceive a virtual character as socially present, they may be more likely to form relatively stable trust judgments, which are in turn associated with higher levels of interaction intention.

At the same time, several additional findings and interpretations emerge. First, gaze dynamics show a limited effect on social presence, which to some extent diverges from prior research suggesting that richer nonverbal cues are associated with higher perceived presence [63]. However, previous studies indicate that, in the absence of responsiveness, mere behavioral variation in virtual agents does not necessarily enhance social experience, whereas responsive behavior can elicit stronger social presence [94]. This pattern may suggest that, in virtual idol livestreaming contexts—characterized by non-immersive and one-to-many interaction—gaze dynamics lack a responsive basis and therefore may not be readily translated into users' perception of social presence.

Second, gaze dynamics appear to be associated with trust judgments. This finding is broadly consistent with prior research suggesting that dynamic variations in nonverbal behavior may be associated with trust perception [95]. At the same time, predictability and consistency of behavior are considered important conditions in the process of trust formation [96]. One possible interpretation is that excessively rapid gaze shifts in virtual idol livestreaming may reduce the perceived stability of behavioral signals, which may in turn be associated with lower levels of trust.

Third, gaze dynamics show a limited effect on interaction intention and may even be associated with reduced interaction intention under high-dynamic conditions. In prior research, gaze shifts and reorientation have been considered to facilitate turn-taking coordination by signaling the transfer of speaking rights [39,40]. However, such functions are typically grounded in responsive, reciprocal interaction. In the present one-to-many livestreaming setting, this function may be less salient. In addition, it is possible that frequently changing visual cues may be associated with cognitive demands placed on viewers during information processing. Given the limited capacity of working memory when processing dynamic information [97], higher frequencies of visual change may be associated with reduced clarity in perceived interaction context and lower willingness to engage.

Fourth, gaze dynamics moderate the effect magnitude of gaze intensity. Specifically, when the two are aligned (e.g., high intensity combined with low dynamics), individuals exhibit relatively higher levels of interaction intention; when they are mismatched, the effect appears weaker. This finding is consistent with prior research indicating that multiple nonverbal cues interact and jointly influence individuals' interpretation of social information [98]. At the same time, nonverbal communication has long been conceptualized as an integrated multi-channel system, in which effective interaction depends on the consistency across channels; conflicting signals may reduce communicative effectiveness [99]. This pattern may suggest that there may exist a coordination range between gaze intensity and gaze dynamics, within which gaze behavior is more likely to be associated with relatively positive outcomes.

Taken together, these findings suggest that, within the controlled experimental simulation of virtual idol livestreaming contexts characterized by non-immersive and one-to-many interaction, the patterns of nonverbal behavior may not fully align with the dynamic regulation processes typically observed in human–human interaction. Compared to behavioral variation itself, users may rely more on relatively stable perceptual cues when forming social judgments, whereas high-frequency behavioral changes may interfere with this process and be associated with lower levels of trust and interaction intention.

7. Practical Implications and Future Research

This study provides practical implications for the design, production, and operational management of virtual idol livestreams through systematic analysis of gaze strategies.

(1) Providing an empirical basis for behavioral design considerations in virtual idols.

This study provides experimental evidence that gaze-related cues in virtual idol livestreaming are associated with viewers' social–cognitive responses. Rather than establishing generalizable mechanisms, these findings offer context-specific support for understanding virtual idols as interactive agents whose observable behaviors may shape user perception. In this sense, the results can inform subsequent explorations of behavior-oriented design in virtual idol development.

(2) Offering context-specific insights into how gaze strategies may be associated with online interaction intention.

The findings suggest that gaze strategies may be associated with online interaction intention through their associations with perceived gaze, social presence, and trust. While this pathway represents a context-bounded empirical pattern rather than a universally established mechanism, it indicates that gaze can function as a potentially adjustable performance parameter in livestreaming design. In highly interactive segments, such as real-time chatting or audience engagement, higher gaze intensity combined with relatively stable gaze patterns may contribute to stronger perceived attention and interaction willingness. In contrast, in less interactive segments (e.g., narration or gameplay), relatively reduced gaze intensity and moderate gaze variation may help maintain viewer focus on content without introducing excessive attentional disruption.

(3) Suggesting design considerations for persona differentiation in virtual idols.

Consistent non-verbal expressions play an important role in shaping and maintaining virtual idol personas, and gaze strategies may contribute to how character sociality is perceived. Accordingly, gaze can be considered as one of several parameters in persona construction. For instance, a "listener-type" persona may benefit from relatively sustained and stable gaze patterns that reinforce impressions of attentiveness, whereas a "professional-type" persona may be associated with more controlled and less frequent gaze shifts, which could support perceptions of stability and credibility. These suggestions should be interpreted as exploratory design implications derived from the present find-

ings rather than fixed prescriptions. This study has several limitations that also suggest directions for future research. First, the experimental stimuli were pre-edited clips isolating gaze cues, whereas actual livestreams combine multimodal signals such as voice prosody, facial expressions, and body movements. While this design enhances internal validity by controlling extraneous variables, it may limit ecological validity. In addition, the use of a single virtual idol as the stimulus may further constrain the generalizability of the findings, as different virtual idols vary in visual style, persona design, and interaction patterns. Future research could incorporate multimodal stimuli and multiple virtual idols to better reflect real livestream environments. Second, the design captured only short-term exposure and could not assess potential changes in attention, trust, or interaction patterns arising from prolonged engagement. Longitudinal or repeated-exposure designs would help verify the durability of these findings. Third, the sample was restricted to Chinese respondents and did not account for potential differences in how gaze behaviors are socially interpreted across cultural contexts. As a result, the effects of gaze strategies may be conditioned by culture-specific norms. Future research could employ cross-cultural samples to examine the stability of the proposed model across different cultural settings. Fourth, data were collected from a single online platform, without considering potential differences in audience perceptions and attitudes toward virtual idols across platforms. This may introduce platform-specific community effects and limit the generalizability of the findings. Future studies could extend data collection to multiple platforms and countries, examining virtual idol communities across diverse online environments. Furthermore, the study relied on self-reported measures collected within a single session, which may raise concerns about common method bias. In addition, some constructs—particularly perceived gaze and social presence—are both based on subjective perception and may exhibit potential conceptual overlap. Although discriminant validity was statistically supported, future research could employ multi-method approaches to further distinguish these constructs.

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Institutional Review Board Statement: Although all authors are currently affiliated with institutions in Korea, the present study was conducted with participants based in China. According to the Ethical Review Measures for Life Sciences and Medical Research Involving Humans issued by the National Health Commission of China (February 2023), ethical review and approval are exempted for research involving de-identified and anonymous data that poses no more than minimal risk to participants. The full regulation is available at https://www.gov.cn/zhengce/2023-02/28/content_5743660.htm (accessed on 24 February 2025). In addition, this study complies with the Bioethics and Safety Act of Korea (Article 15(1), Chapter 2). At the time of the questionnaire survey, all participants were informed of the study and provided consent for the use of their data.

Informed Consent Statement: In-formed consent was obtained from all subjects involved in the study.

Data Availability Statement: The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

TR	Trust
SP	Social Presence
OI	Online Interaction Intention
PG	Perceived Gaze
GI	Gaze Intensity
GD	Gaze Dynamics
ID	Gaze Intensity × Gaze Dynamics

Appendix A

Questionnaire

Table A1. Questionnaire items and sources.

Construct	Item	Questionnaire Source
Perceived Gaze	I felt that the streamer was aware of me. I felt that the streamer was looking at me. I felt that the streamer was paying attention to me.	[14]
Social Presence	I felt that the streamer's presence was real. I sensed human warmth in the streamer's gaze. I felt that the streamer had genuine emotions. I felt interpersonal contact during the viewing.	[15,18]
Trust	I believed that the streamer was reliable and trustworthy. I believed that the streamer's behavior was sincere and honest. I felt that the streamer cared about me during the performance. I felt that I could rely on the streamer emotionally.	[78,89]
Online Interaction Intention	I would communicate with the streamer or other viewers and share my opinions. I would respond to questions from the streamer or other viewers. I would express my feelings in the livestream chat. I would pay for content recommended by the virtual idol. I might give virtual gifts (tipping) to the streamer.	[18,71]

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