Intricate Eye Features and its Effect on Realism of Look Alike Avatars

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Figure 1: Normal, Random, and Static Eye Movement in Look-Alike Avatars (Full Face and Midface))

ABSTRACT

The fidelity of a look-alike avatar can affect how comfortable users feel when they engage with an avatar that resembles them. This is important as developers continue to make virtual immersive experiences that are personalized to the user. To minimize the Uncanny Valley effect, non-verbal cues, intricate features, and varying fidelity levels must be considered. This study investigates how eye movements influence perceived realism and comfort in look-alike avatars. Using motion capture/direct manipulation, we compare static, normal, and random eye movements in a social context-based scenario. Participants analyzed self-introduction videos of male and female avatars, one full-faced and one cropped at the eyes, with varying eye movements. Thirty-three participants rated the avatars on realism and comfort, highlighting the importance of realistic eye movements in enhancing user experience and comfort in social contexts. This is important to measure as virtual environments allow for social activities and interaction between users.

CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**; • **Computing methodologies** → *Perception*.

KEYWORDS

Look alike avatar, eye movement, virtual reality, perceived realism

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1 INTRODUCTION

The realism of look-alike avatars holds significant importance across multiple domains, including gaming, virtual reality, and online communication. This relevance brings to the forefront the phenomenon of the Uncanny Valley effect, wherein the boundary between a life-like avatar and one that teeters between human and non-human characteristics becomes critical. Avatars devoid of any emotion - due to a lack of facial expressions, eye movements, or both - are perceived as unsettling and may cause discomfort, which contributes to the Uncanny Valley effect. As these features are incorporated, the unnerving feeling diminishes as the look-alike avatar's perceived realism increases. Despite this being widely known and studied, many are limited in actually achieving accurate realistic results as it is challenging to replicate incredibly life-like avatars. Despite this, there are factors that humans possess that allow us to easily decipher an avatar from a human being, factors such as nonverbal cues and intricate facial expressions. These subtle nuances can make or break the perceived realism of a given avatar, even more so if an avatar resembles one's self or someone familiar to them as users are more likely to scrutinize avatars that closely resemble real people. Hyperfocusing on specific avatar features adds challenges in maintaining believability, essential for creating realistic avatars that users feel comfortable representing themselves. Prior research that has been done looks into the role of eye movements on topics like behavioral realism and gaze impact which proves that it is to be considered but, they don't delve into how different kinds of eye movements impact how look-alike avatars are perceived which adds an important yet overlooked aspect.

2 RELATED WORK

As technology advances, a key aspect is reducing the discomfort look-alike avatars bring by creating more human-like behaviors and emotions. Rae et al. incorporated naturalistic gaze behaviors (saccades, direction, duration, etc.) in their avatars and used three types of gaze controls and found that the model-generated gaze was perceived as more normal, friendly, and outgoing meanwhile the stationary gaze was perceived as lifeless and the random gaze as unstable. It was also noted that avatars whose gaze cues directly matched that of the conversation enhanced the quality of communication better than the random gaze [8]. Thus, it showcases how vital eye movements are in improving the engagement between humans and their look-alike avatars. Other studies found normal eye movements, such as microsaccades, is more easily detected by humans [10], this can be incorporated in look-alike avatars to enhance their perceived realism. Especially pinpointing the significance of further focusing on facial expression and eye movements compared to other aspects of avatar representation. [4] Majaranta et al. studied how human-computer interaction (HCI) can track users' eye movements to assess engagement. They explored various normal eye movements, such as gazes, saccades, etc. which informed our selection of normal eye movements for our study. These studies showcase the positive effects of incorporating natural eye movements on avatars since it increases user engagement and enhances positive impressions [6].

Dzardonova et al. studied the impact of non-verbal cues (NVCs) on the perceived realism of virtual characters. They found that NVCs enhance communication and user engagement, slightly increasing the perceived realism of the avatar's gaze and reducing discomfort. However, this change was likely due to the avatar's emotional tone rather than just its facial expression or eye movements. [3]. Another study on non-verbal cues (NVCs) and avatar realism evaluated viewer perception of different eye movements in six avatars. It concluded that avatars with higher perceived eye contact were rated more favorably. However, avatars with no eye animation also ranked relatively high, likely due to the inclusion of head movements and blinking that obscured eye movements.[2] Barrett et al. found that artificial eye expressions help understand user perception of visual and behavioral signals. Participants often mistook emotions (disgust for happiness, fear for surprise), highlighting how slight inaccuracies can shift an avatar's fidelity from realistic to uncanny.[1] A similar study was done by Sonia et al. where they found that although certain emotions, such as anger and disgust, were more likely to be incorrectly guessed on average, there was no significant difference in guessing the facial expressions of each actor to their look-alike avatar. [11] This showcases that avatars can't always properly convey their intended emotions, nor can users always pick up on an avatar's intentions based solely on their facial expressions.

Mathis et al. conducted an online study with avatars ranging from realistic to abstract, performing various gestures. They found that realistic avatars' eyes were perceived as more realistic and that avatar fidelity is crucial for social interactions, evoking stronger acceptance of virtual body ownership. [7]. A similar study supported this claim by adding that users view avatars as the virtual representation of themselves, which is seen through customization. This enhances user engagement when interacting in a virtual environment such as the metaverse.[5] Roth et al. investigated the social gaze of look-alike avatars in dyadic virtual interactions, asking participants to evaluate the avatar's humanness. They found that avatars displaying normal eye movements were interpreted more positively, confirming their hypothesis that natural gaze behavior is superior to other models, while random gaze is inferior. [9]

3 METHODS

3.1 Participants

33 respondents' data was collected through an anonymous survey. The survey was sent with an anonymous link through multiple platforms (email, direct message, etc.)

3.2 Materials

Two virtual look-alike avatars, one male and one female, were created using Reallusion's Character Creator (v 4.42). The Headshot plugin (v 2.01) was used to make the avatars visually similar to the models. These avatars were transferred to iClone (v 8.42) for facial animation using the Live Link Face app (v 1.1.0) on an iPhone 11, which tracks the models' faces and transfers the facial mocap data to Reallusion. To manipulate eye movements (static, normal, random), we used the Facial Puppet feature in iClone. For accurate lip syncs in the avatar introduction videos, we utilized the Acculips feature in iClone.

This study investigates how realistic eye movements contribute to higher perceived realism in look-alike avatars and how this can ultimately, increase the comfortability of the avatar to the users. To execute this we isolated different types of eye movement into three different types (Static, Normal, and Random eye movement) with the most "realistic" eye movement being the movement that maintains the most normalcy. In our context that would be normal eye movement.

An anonymous survey was conducted through Qualtrics. All rules were listed to the participants and concepts were defined to the participants beforehand. Participants were shown videos of the generated look-alike avatars' faces and cropped videos of it's mid face. We do this so participants can compare the varying eye movements more closely without the added facial features. The participants were shown a video of the look-alike avatar introducing themselves. The male and female avatar cropped and full face videos were completely randomized. Each introduction video spans around 50 seconds and immediately after viewing each video participants were asked a series of questions to get their initial reactions to the avatars.

3.3 Procedures and Measures

The video recordings remained the same with only the eyes being manipulated to display the intended movement. The script for the audio recording will be kept constant between the male and female avatars. The eye movements will change each time. There will be 6 videos in total (3 for the male avatar; and 3 for the female avatar). The survey will be used to see how varying eye movements make the users feel.

Questionnaires and Surveys: At the beginning of the survey we asked a few pre-experiment questions. We asked our similarity question beforehand allowing participants to rank similarity from 1-10 (not at all to completely) to gauge how closely the avatars resembled the models. Following each video, participants will be asked to complete applicable questionnaires to elicit responses regarding realism and comfortability.

Realism. We measure the level of realism of the look-alike avatars with the corresponding eye movements using a 5-point Likert scale, ranging from 1 (least realistic) to 5 (most realistic): (i) How realistic did you find this avatar?

Comfortability. We measure the extent to which participants feel comfortable with the avatar after the introduction using a 5-point Likert scale, ranging from 1 (not at all) to 5 (completely): (i) How comfortable do you feel with the avatar after watching this video?

At the end of the questionnaire, we will ask the participants to match the avatar introduction video to the eye movement they feel the video displays.

4 RESULTS AND ANALYSIS

We used a repeated measures design with three independent variables: (i)Avatar gender (female and male); (ii)Video type (Full and cropped); (iii) Eye movement (Normal, Static, and Random). These three variables were treated as categorical independent variables while perceived realism and comfort levels as ordinal dependent variables. We conducted an ordinal logistic regression of the perceived realism and comfort levels on the independent variables using SPSS software. The goodness of fit statistics indicated that both models provided an adequate fit to the data. For the perceived realism model, the deviance was 31.877 (df = 33), and the Pearson Chi-Square was 26.860 (df = 33), indicating a good fit. For the comfort model, the deviance was 26.051 (df = 33), and the Pearson Chi-Square was 25.127 (df = 33), also suggesting a good fit. These statistics suggest that the models are appropriately fitting the data and that the independent variables can explain the variations in the dependent variables. Two generalized linear models were used to analyze the main effects of our independent variables, as well as their interactions, on perceived realism and comfort levels. The main effects and interactions for the independent variables were examined using Type III Likelihood Ratio Chi-Square tests.

It's important to note pre-similarity rankings because we analyze our variables on look-alike avatars. The pre-similarity ranking means in Table 3 (see table 3) reveal that male avatars (mean: 6.76) were perceived as more similar to their models than female avatars (mean: 5.76). The standard deviations (1.81 for males and 1.95 for females) indicate notable variability in participants' ratings, with greater diversity in perceptions of female avatars. These findings provide a baseline understanding of perceived similarity before experimental manipulations, highlighting the importance of considering individual differences and potential biases in future analyses.

4.1 Percieved Realism

For perceived realism, the effect of eye movement on perceived realism was not significant ($X^2(1) = 1.243$, $p = .265$), indicating that the type of eye movement alone does not significantly influence perceived realism. The effect of video type approached significance ($X^2(1) = 3.525$, $p = .060$), suggesting that whether the avatar video was cropped or full face may influence perceived realism. Although not statistically significant, this result implies a potential trend where the removal or addition of facial features could affect how realistic participants perceive the avatars. Furthermore, the interaction effects between video type and eye movement ($X^2(2) = 2.713$, $p = .258$), as well as between avatar gender and video type ($X^2(2) = .869$, $p = .648$), were not significant, suggesting that the combination of these factors does not significantly impact perceived realism.

Although the parameter estimates do not show statistical significance overall, random eye movements had a significantly negative effect on perceived realism ($B = -1.545$, $p < .001$), indicating that they decreased perceived realism. Participants perceived avatars with random eye movements as less realistic compared to those with normal or static movements. While normal and static eye movements did not show significant effects individually, the overall pattern suggests normal movements may be perceived as more realistic. To illustrate this trend, Table 2 compares the mean ranking and standard deviation of realism for the avatar introduction videos (see Table 2).

Pre Similarity Rankings		
	Male	Female
Mean	6.76	5.76
Standard Deviation	1.81	1.95

Table 1: Mean and Standard deviation of pre similarity rankings of the avatars

	Realism			
	Full face Female	Cropped Female	Full face Male	Cropped Male
Normal	Mean: 3.48	Mean: 4.33	Mean: 2.67	Mean: 4.25
	SD: 1	SD: 1	SD: 1	SD: 1
Random	Mean: 2.33	Mean: 2.85	Mean: 2.24	Mean: 2.33
	SD: 1	SD: 1	SD: 1	SD: 1
Static	Mean: 2.82	Mean: 2.79	Mean: 3.00	Mean: 2.70
	SD: 1	SD: 1	SD: 1	SD: 1

Table 2: Mean and Standard deviation of realism rankings

	Comfort			
	Full face Female	Cropped Female	Full face Male	Cropped Male
Normal	Mean: 3.67	Mean: 3.67	Mean: 2.60	Mean: 2.60
	SD: 2	SD: 2	SD: 2	SD: 2
Random	Mean: 2.39	Mean: 2.76	Mean: 2.33	Mean: 2.30
	SD: 1	SD: 1	SD: 1	SD: 1
Static	Mean: 2.88	Mean: 3.12	Mean: 3.03	Mean: 2.61
	SD: 2	SD: 1	SD: 1	SD: 1

Table 3: Mean and Standard deviation of comfort rankings

4.2 Comfort Levels

In terms of comfort levels, the effect of eye movement on comfort levels was marginally significant ($X^2(1) = 3.853$, $p = .050$), suggesting that different types of eye movements might influence comfort levels. This marginal significance indicates that eye movements could play a role in how comfortable participants feel, although further research is needed to confirm this effect. The video type had a significant effect ($X^2(1) = 4.284$, $p = .038$), indicating that participants felt more comfortable with one video type over the other(cropped over full). This result, similar to realism, highlights the importance of the removal or addition of facial features in influencing user comfort. The interaction effects for comfort levels were not significant, with the interaction between video type and eye movement ($X^2(2) = .125$, $p = .940$) and between avatar gender and video type ($X^2(2) = .748$, $p = .688$) showing no significant impact on comfort levels.

Random eye movements had a significantly negative effect on comfort ($B = -1.405$, $p = .002$), indicating they decrease comfort levels. Participants felt less comfortable with avatars exhibiting random eye movements. While normal eye movements did not show a significant effect individually, they contributed to a trend suggesting that more natural movements might enhance comfort. Static eye movements also did not show a significant effect but data suggests that less dynamic (static) movements may be less favorable compared to normal movements. Table 3 illustrates the trend in comfort rankings for the avatar introduction videos (see Table 3).

5 DISCUSSIONS

Eye movements are crucial for non-verbal communication. This study examined three types: normal, static, and random. Findings show that random eye movements significantly decrease perceived realism and comfort. Participants found avatars with random eye movements less realistic and felt less comfortable with them. This suggests that unnatural eye movements disrupt the lifelike illusion, potentially triggering discomfort and the Uncanny Valley effect. In contrast, normal eye movements, which simulate natural human eye behavior, were found to enhance both realism and comfort, although the effects were not always individually significant. The data suggests a trend where more natural eye movements contribute positively to the participants' experience, making the avatars appear more lifelike and thereby increasing user comfort. This finding aligns with existing literature that emphasizes the importance of subtle, naturalistic behaviors in creating believable virtual characters. [1] Static eye movements did not significantly impact perceived realism and comfort individually. However, the overall pattern suggests they are less favorable than normal movements. This may be because static movements fail to replicate the dynamic nature of real human eyes, making the avatar seem less interactive and engaging. The interactions between the variables were generally not significant, indicating that their combinations do not substantially influence perceived realism or comfort. While the visual presentation of the avatar (cropped vs. full face) and avatar gender are important, eye movement type remains a predominant factor in shaping user perceptions. Realism and comfort do not always correlate, suggesting they are distinct concepts. These results emphasize the importance of realistic eye movements in creating believable and comfortable virtual characters. The significant negative impact of random eye movements highlights the need for careful design of eye behaviors in avatars. Implementing more natural eye movements can enhance user experience, making avatars appear more lifelike and engaging. It is important to note that participants we largely able to match the avatar videos to the specified eye movements at the end of the survey.

6 CONCLUSION AND FUTURE WORK

This study highlights the critical role of varying eye movements in influencing the perceived realism and comfort of look-alike avatars. Results from social context-based scenario videos show the importance of realistic eye movements in enhancing user experience. Creating avatars with naturalistic eye behaviors makes them more engaging and believable. These findings provide insights into how users might respond in real social situations, capturing genuine perceptions of realism and comfort. Several limitations should be considered when generalizing the results of this study. One limitation was gender representation; Our pre-experimental survey showed more female participants, which might have introduced gender bias. In our study, independent variables outside of eye movements did not significantly affect comfort and realism. Future research should explore other variables along with eye movements to better understand their impact on user perceptions. Future studies should additionally seek to improve user engagement if following a similar methodology to our own. Participant feedback indicated the introduction videos in the survey were long and the questions were a little repetitive. These factors likely attributed to lower user engagement in our study as participants might not have watched the videos to completion. We see the casualty of this as we had many incomplete survey responses that needed to be removed, decreasing the sample size. Future work may further investigate the impact of varying eye movements on the expressive fidelity of an avatar along with its' perception since previous work has shown the fidelity of an avatar can be impacted by non-verbal cues such as eye movements. [3]

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