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Social anxiety and eye avoidance during virtual communication: Evidence from an eye-tracking study

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ABSTRACT

Despite evidence linking social anxiety to atypical gaze behaviours, its manifestation during virtual communication remains unclear. Using a quasi-experimental between-group design, this study examined the effect of social anxiety levels on gaze behaviour among 55 participants with high or low social anxiety symptoms. The participants' eye movements were recorded during the virtual communication task using the Tobii Pro Fusion eye-tracking system. The analysis focused on six eye-movement measures across four predefined areas of interest. The findings revealed significant variations in gaze behaviour between the groups. Participants with high social anxiety exhibited shorter fixation and visit durations on the eyes, while participants with low social anxiety showed shorter first fixation durations on both the eyes and the nose. Additional analysis revealed a negative relationship, suggesting that increased social anxiety was associated with a decrease in fixation and visit duration for the eyes. The eye region was found to be sensitive in socially anxious individuals, revealing tendencies for eye avoidance and a direct correlation between the severity of social anxiety symptoms. This study offers valuable insight into gaze dynamics during online communication among individuals with social anxiety.

Keywords: social anxiety, gaze, eye-tracking, avoidance, attentional bias

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1 INTRODUCTION

Eye-gaze is a crucial component of social interactions (Anas et al., 2016). This is because eye-gaze serves a dual function, enabling individuals to convey their mental and emotional states while also directing their attention towards a specific object or direction (Çakır & Huckauf, 2023). Consequently, impaired gaze behaviour has been associated with reduced social performance, especially in psychological disorders such as social anxiety, in which altered gaze behaviours are frequently exhibited and can be considered a supporting feature in the diagnostic process (American Psychiatric Association, 2013; Chen et al., 2022).

Social anxiety is characterised by a persistent and disproportionate fear of rejection and unfavourable judgments from others, leading individuals to avoid social and performance-related situations that could potentially expose them to scrutiny, humiliation, and negative evaluations (American Psychiatric Association, 2013). Its global prevalence has increased significantly over the years and has been reported to be exacerbated by the COVID-19 pandemic (Javaid et al., 2023; Santomauro et al., 2021).

According to prominent cognitive and behavioural models of social anxiety, the development and maintenance of the disorder's pathological symptoms are attributed to the presence of atypical gaze behaviour (Clark & Wells, 1995; Heimberg et al., 2014; Rapee & Heimberg, 1997; Spence & Rapee, 2016). However, these models introduce variations in their proposed characteristics. For instance, one of the proposed models emphasised the avoidance of threat-related information. Whereas, according to another model, there is a tendency for rapid orienting and difficulties in disengaging from threat (Clark & Wells, 1995; Rapee & Heimberg, 1997). In summary, despite these differences, these models concur that socially anxious individuals exhibit atypical eye-gaze patterns that contribute to the maintenance of the disorder.

Extensive eye-tracking research has revealed significant insights into the gaze behaviours of individuals with social anxiety. However, understanding its precise nature and manifestation has been shown to be a relatively complex issue, given the frequent contradictory findings reported (Konovalova et al., 2021). Recent systematic reviews have indicated a spectrum of findings from prior studies, ranging from avoidance to increased eye-gaze behaviour among those with social anxiety (Chen et al., 2020; Günther et al., 2021). Importantly, these studies primarily involved face-viewing tasks using static facial stimuli and often lacked the dynamic and interactive components that constitute the fundamental aspects of authentic social interactions.

Recent studies conducted in more naturalistic settings, such as face-to-face interactions, have yielded mixed findings (Konovalova et al., 2021; Rösler et al., 2021). Konovalova et al.(2021) reported a reduction in the number of fixations on the head region in the presence of a confederate. However, another study observed an increase in fixations on the head throughout the interaction (Rösler et al., 2021). These studies are somewhat limited in their predefined areas of interest, focusing primarily on the head and body areas while overlooking more detailed facial characteristics. Additionally, it is worth considering that alterations in eye-gaze may be influenced

by the context in which the interaction takes place, especially in situations perceived as more threatening for individuals with social anxiety, such as within a virtual context (Azriel et al., 2020).

Initial evidence regarding virtual context included the implementation of a live video connection (Hessels et al., 2019; Howell et al., 2015). Findings from both studies indicate a reduction in eye-gaze among individuals with higher levels of social anxiety during interactions. However, these findings have limitations in the eye-movement parameters included, as they primarily focused on fixation durations and counts, with both studies emphasising avoidance behaviours. Notably, the initial period of gaze behaviour during information processing was not included in the eye-gaze data (Konovalova et al., 2021). Similar limitations were also observed in more recent studies, in which eye-gaze parameters were restricted to avoidance measures only (Azriel et al., 2020).

To date, the methodological approaches employed in research on social anxiety and gaze behaviours have varied and been shown to possess limitations, leading to uncertainty (Gregory et al., 2018). To our knowledge, there is a need for further exploration that adopts a more comprehensive and ecologically valid approach, given the complexities of its relationship. Therefore, this study aimed to examine the influence of social anxiety on gaze behaviour by investigating eye-movement measures across specific areas of interest (AOI). The study involved a comparison of these measures between two participant groups, specifically distinguishing between individuals with high and low social anxiety during a virtual communication task.

2 METHODS

2.1 Participants and Design

A total of 55 students from the Universiti Sains Malaysia Health Campus in Kelantan, Malaysia, took part in the study. Participants were recruited using purposive sampling and were required to be over 18 years of age, proficient in English, and to have scored above 30 on the Leibowitz Social Anxiety Scale (LSAS). The LSAS was found to be useful as a screening tool for assessing social anxiety in a similar context to the current study (Isa et al., 2021). The exclusion criteria were the presence of current or historical neurological/psychiatric disorders, eye-movement abnormalities, visual impairments, or prior eye surgeries. Participants were categorised into two groups based on their LSAS scores: those with scores of 60 and above, denoted High Social Anxiety (HSA) (29 participants) and those with scores ranging from 30 to 59, indicated Low Social Anxiety (LSA) (26 participants). The optimal LSAS cut-off score of 60 indicates a significant presentation of social anxiety symptoms, whereas an LSAS score below 30 suggests the absence of such symptoms (Mennin et al., 2002). Based on this cut-off score, therefore, the score range between 30 and 59 was operationally defined as the low social anxiety group. Although this range partially overlaps with the mild to moderate classification in the original LSAS instrument, the groups were designed to allow meaningful comparison between individuals with relatively lower versus higher social anxiety, rather than to establish a clinical diagnosis. Demographic details of the participants are presented in Table 1.

The study employed a quasi-experimental between-group design, allowing comparison of behavioural differences between the high and low social anxiety groups based on their LSAS scores. The design did not involve random assignment, reflecting the quasi-experimental nature of the study.

Table 1. Demographic information of participants.

Demographic	N	Percentage (%)
Gender:		
Female	39	70.9
Male	16	29.1
Age Group:		
18-25	47	85.5
26-30	6	10.9
31-35	1	1.8
46-50	1	1.8
Ethnicity:		
Malay	31	56.4
Chinese	12	21.8
Indian	12	21.8
Education Level:		
Diploma or pre-university (e.g., Foundation/ A-levels)	7	12.7
Undergraduate (e.g., Degree)	43	78.2
Postgraduate (e.g., Master's/Ph.D.)	5	9.1
Social Anxiety Score:		
High Social Anxiety	29	52.7
Low Social Anxiety	26	47.3

2.2 Visual Stimulus

A pre-recorded video featuring a female confederate recruited and compensated by the researcher was created. To minimise potential distractions, the confederate maintained minimal body movements, sat against a plain background, and wore a plain t-shirt (see Figure 1). The development process prioritised clear audio recordings and sufficient yet unobtrusive lighting. The stimulus exclusively focused on the upper body region of the confederate, encompassing the head and the upper torso.

The stimulus involved the simulation of a virtual communication task. This task comprised an initial greeting, self-introduction, and a set of ten predefined questions derived from a prior study by Aron et al., adapted to align with local contextual relevance (Aron et al., 1997; Chen, et al., 2023). Following each question, a 15-second interval provided participants with the opportunity to respond, during which the confederate refrained from intervening, but occasionally expressed acknowledgement with nodding gestures. For specific questions, the confederate offered brief validating remarks in response to the participants' answers, thereby enhancing the simulation of a virtual communication task.



Figure 1. An example of the video stimuli.

2.3 Experimental Setup

The participants were seated in chairs facing a monitor screen. A Liquid Crystal Display monitor (Samsung S24F350FHE, 24-inch LCD at a resolution of 1920 x 1080 pixels, with a refresh rate of 60 Hz) was positioned 70 cm from the participant. The eye-tracker was placed beneath the monitor frame, with an operational distance ranging from 50 to 80 cm from the reference point. Eye movements were recorded using Tobii Pro Fusion, a screen-based eye-tracking system suited for involving real-world stimuli. Equipped with two eye-tracking cameras (Tobii EyeSensor Modules), it enhances precision levels and compensates for head movements during recording. The eye tracker features two pupil tracking modes (bright and dark pupil illumination modes), offering superior tracking robustness. Another laptop was installed to facilitate researcher control over the testing environment, allowing for continuous monitoring of each participant.

2.4 Experimental Procedure

Each recording session began with a 9-point individual calibration procedure to optimise gaze estimation algorithms and accommodate individual variations in the human eye. Prior to this, participants were comprehensively briefed on the nature of the study and provided written informed consent to participate. After calibration, participants were presented with on-screen task instructions, followed by a brief fixation cross (500 ms) at the centre of the screen. They then engaged in a virtual communication task, responding to questions posed by the confederate during

the stimulus presentation. Notably, only eye-tracking data from the stimulus phase were included in the data analysis. The entire procedure lasted approximately 20 minutes for each participant and was concluded with a blank screen (0.5 s) and a thank-you message (see Figure 2). Participants were offered honorarium upon completion of the study. The study protocol was approved by the Human Research Ethics Committee (USM/JEPeM/22100658).

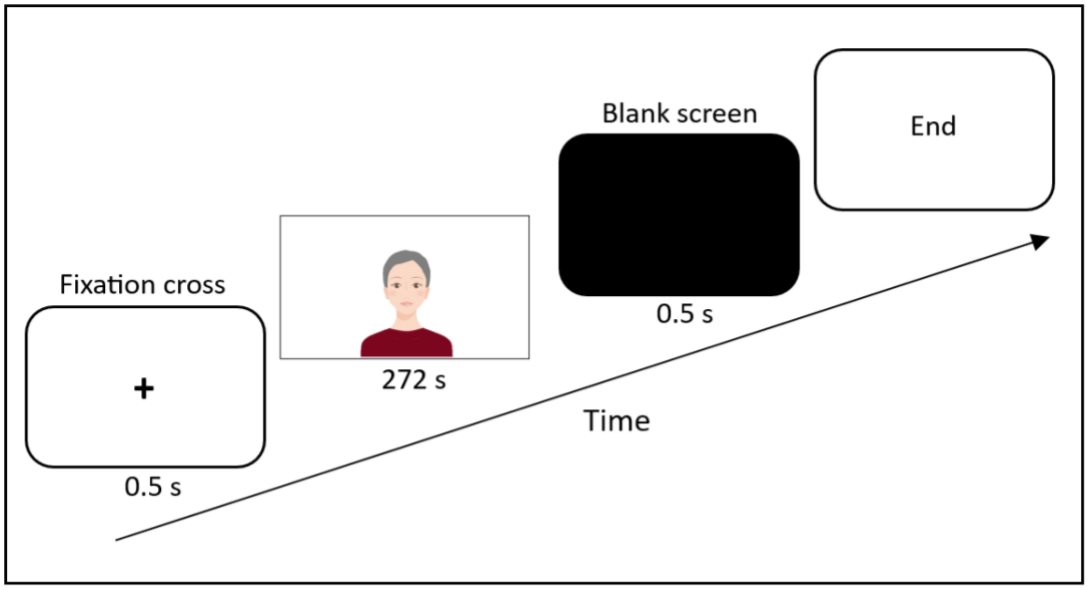


Figure 2. Sequence of experimental trial.

2.5 Eye-Movement Measures

Tobii Pro Lab software (v 1.207), running on the Windows operating system, was used to record and analyse eye-gaze data. (Tobii AB, 2023) The AOIs analysed were specific to the central region of the face: the Eyes, Mouth, Nose, and Forehead (see Figure 3). Data collected from the software for six eye-movement measures (Fixation Count, Fixation Duration, Time to First Fixation, First Fixation Duration, Visit Count, and Visit Duration) were subsequently extracted for further analysis.

1. Fixation Count: The number of fixations occurring in an AOI during an interval (counts)
2. Fixation Duration: The total duration of the fixations inside an AOI during an interval (ms)
3. Time to First Fixation: The time to the first fixation inside an AOI during an interval (ms)
4. First Fixation Duration: The duration of the first fixation inside an AOI during an interval (ms)
5. Visit Count: The number of visits occurring in an AOI during an interval (counts)
6. Visit Duration: The total duration of the visits inside an AOI during an interval (ms)

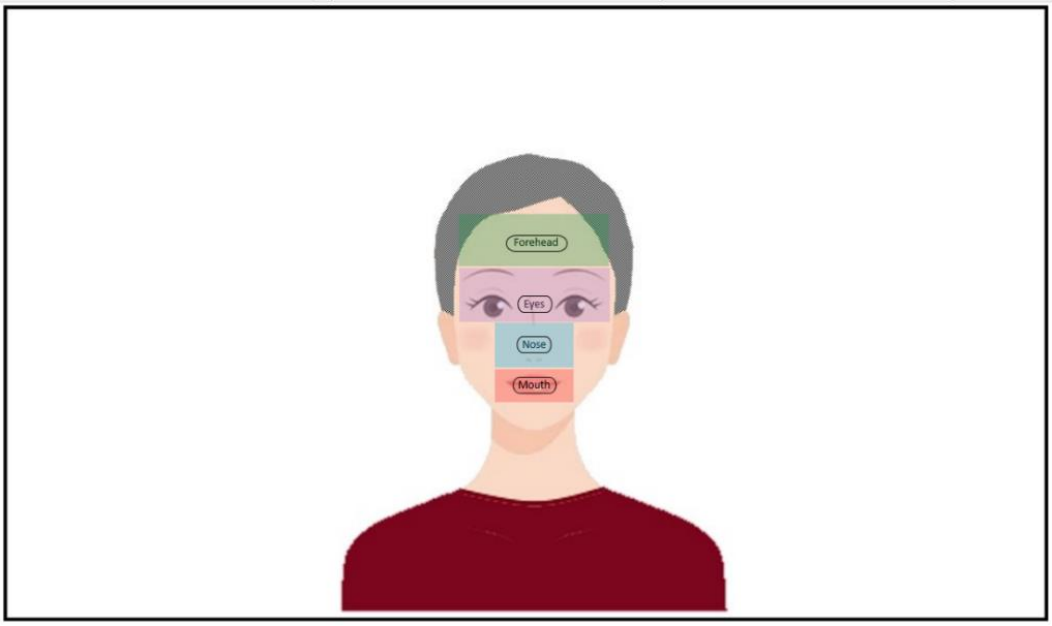


Figure 3. Example of AOIs used for eye-gaze analyses depicted in a sample illustration.

2.6 Data Analysis

Statistical analyses were conducted using SPSS version 27 for both the descriptive and inferential assessments. Univariate analyses employing one-way ANOVA were conducted separately for each participant group. In these analyses, AOIs served as independent variables, whereas eye-movement measures functioned as dependent variables. This approach allowed for a focused examination of attentional patterns across distinct AOIs for each social anxiety group. Post-hoc analysis was performed using Tukey's HSD test to identify differences between AOIs. The significance level for all analyses was set at $p < .05$.

Bivariate analyses using Pearson's correlation were used to assess attentional bias among participants by examining the relationship between social anxiety scores and specific eye movement measurements: fixation duration and visit duration. These analyses focused on AOIs, specifically the eyes and mouth.

3 RESULTS

The study consistently revealed a statistically significant effect of AOIs on all eye-movement measures in both participant groups (see Table 2). These findings emphasise that, irrespective of their social anxiety scores, participants exhibited distinctive eye-movement patterns based on specific AOI. Descriptive statistics are presented in Table 3.

Table 2. One-way ANOVA results showing the effect of AOIs on eye movement measures among participants with high and low social anxiety.

Eye Movement Measures	High Social Anxiety			Low Social Anxiety		
	F-value	df	*p*-value	F-value	df	*p*-value
Time to First Fixation	14.430	3,112	$p < .001$	12.295	3,100	$p < .001$
Fixation Duration	12.305	3,112	$p < .001$	10.265	3,100	$p < .001$
Fixation Count	11.919	3,112	$p < .001$	10.685	3,100	$p < .001$
First Fixation Duration	4.541	3,112	$p < .05$	1.606	3,100	$p < .001$
Visit Count	23.149	3,112	$p < .001$	18.724	3,100	$p < .001$
Visit Duration	12.677	3,112	$p < .001$	10.765	3,100	$p < .001$

Table 3. Descriptive statistics for eye movement measures among participants with high and low social anxiety, categorised by AOIs.

Eye Movement Measures	Social Anxiety Score	Area of Interest	Mean	*SD*	95% Confidence Interval	
					Lower Bound	Upper Bound
Time to First Fixation	High	Eyes	2.854	6.209	-12.284	17.991
		Forehead	62.693	76.404	47.556	77.831
		Mouth	4.955	7.531	-10.182	20.093
		Nose	6.354	28.947	-8.784	21.492
	Low	Eyes	10.258	41.246	-6.597	27.112
		Forehead	66.704	73.798	49.849	83.558
		Mouth	12.488	18.806	-4.367	29.342
		Nose	1.099	2.107	-15.755	17.954
Fixation Duration	High	Eyes	34.137	49.291	20.562	47.712
		Forehead	.793	.962	-12.782	14.368
		Mouth	58.977	46.195	45.402	72.553
		Nose	37.429	29.679	23.854	51.005
	Low	Eyes	52.329	53.689	37.478	67.181
		Forehead	.577	1.075	-14.274	15.429
		Mouth	48.503	47.634	33.652	63.355
		Nose	42.916	25.981	28.065	57.768
Fixation Count	High	Eyes	100.41	124.410	70.661	130.167
		Forehead	3.76	5.152	-25.994	33.511
		Mouth	118.90	77.853	89.144	148.649
		Nose	80.24	91.661	68.144	127.649

		Eyes	139.00	142.164	102.973	175.027
		Forehead	2.92	6.406	-33.104	38.950
	Low	Mouth	106.88	98.041	70.858	142.912
		Nose	107.46	66.560	71.435	143.489
First Fixation Duration	High	Eyes	.374	.488	.130	.618
		Forehead	.160	.196	-.084	.404
		Mouth	.741	.813	.498	.986
		Nose	.636	.905	.393	.881
	Low	Eyes	.344	.205	.215	.474
		Forehead	.107	.102	-.023	.237
		Mouth	.710	.544	.581	.840
		Nose	.358	.307	.229	.488
Visit Count	High	Eyes	43.48	38.453	32.127	54.839
		Forehead	2.90	3.395	-8.459	14.252
		Mouth	60.41	33.732	49.058	71.770
		Nose	62.28	34.385	50.920	73.632
	Low	Eyes	55.62	41.757	41.453	69.778
		Forehead	2.31	3.886	-11.855	16.470
		Mouth	60.85	47.032	46.684	75.009
		Nose	71.50	36.453	57.338	85.662
Visit Duration	High	Eyes	39901.379	54656.581	24182.591	55620.168
		Forehead	896.586	1164.515	-14822.202	16615.375
		Mouth	69501.517	55045.024	53782.729	85220.306
		Nose	42588.655	35805.609	26869.867	58307.444
	Low	Eyes	63455.192	63186.104	46494.844	80415.541
		Forehead	641.692	1340.109	-16318.656	17602.041
		Mouth	54817.807	53127.795	37857.459	71778.156
		Nose	47092.153	27990.716	30131.805	64052.503

Post-hoc analyses highlighted important group differences in gaze behaviour. Participants with HSA displayed a marginally significant difference, indicating shorter Fixation Durations for the Eyes (M = 34.137, SD = 49.291) than the Mouth (M = 58.977, SD = 46.195), p = .056. Second, participants with LSA exhibited notable distinctions, showing shorter First Fixation Durations for the Eyes (M = 0.344, SD = 0.205) and Nose (M = 0.358, SD = 0.307) relative to the Mouth (M = 0.710, SD = 0.544) ($p < 0.05$ for both comparisons). Finally, among those with HSA, the Eyes (M = 39901.379, SD = 54656.581) demonstrated significantly shorter Visit Durations than the Mouth

(*M* = 69501.517, *SD* = 55045.024) (*p* <.05). Figure 4 illustrates the findings of post-hoc comparisons.

To further explore associations with social anxiety severity, correlation analyses were conducted. A trend approaching significance was observed between social anxiety scores and Fixation Duration on the AOI-Eyes [r(55) = -.217, *p* = .055] (Figure 5 – photo A). Although not reaching conventional significance, a noteworthy negative relationship suggests that, as social anxiety scores increase, there is a tendency towards shorter fixation durations on the eyes. Furthermore, a significant negative correlation was noted between social anxiety scores and Visit Duration on the AOI-Eyes [r(55) = -.237, *p* < .05] (Figure 5 – photo B), indicating that as social anxiety scores increased, visit duration on the eyes became shorter. Together, these findings might potentially explain the avoidance hypothesis of social anxiety, which posits that eye contact is perceived as socially threatening and therefore needs to be avoided.

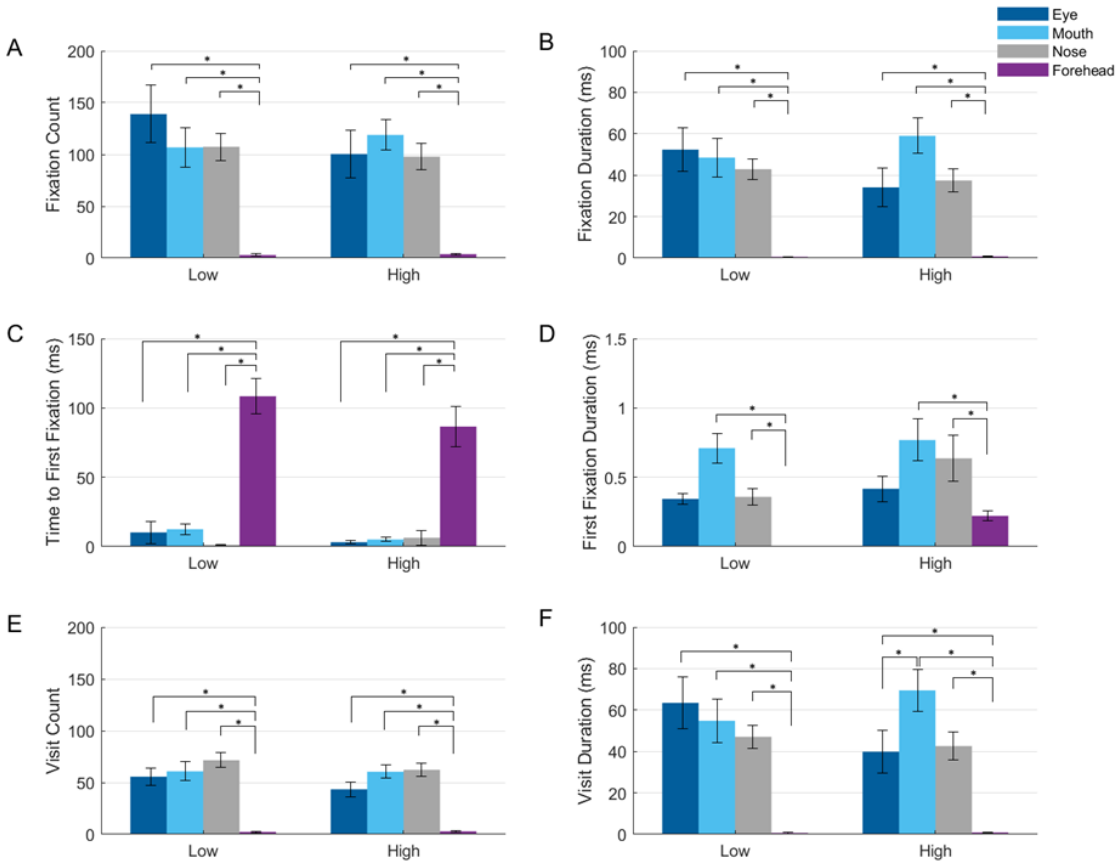


Figure 4. Bar graphs comparing mean values of eye movement measures (A: Fixation Count, B: Fixation Duration, C: Time to First Fixation, D: First Fixation Duration, E: Visit Count, F: Visit Duration) across varying AOIs for each participant group (low and high social anxiety). The error bars indicate the standard error of the mean (SEM).

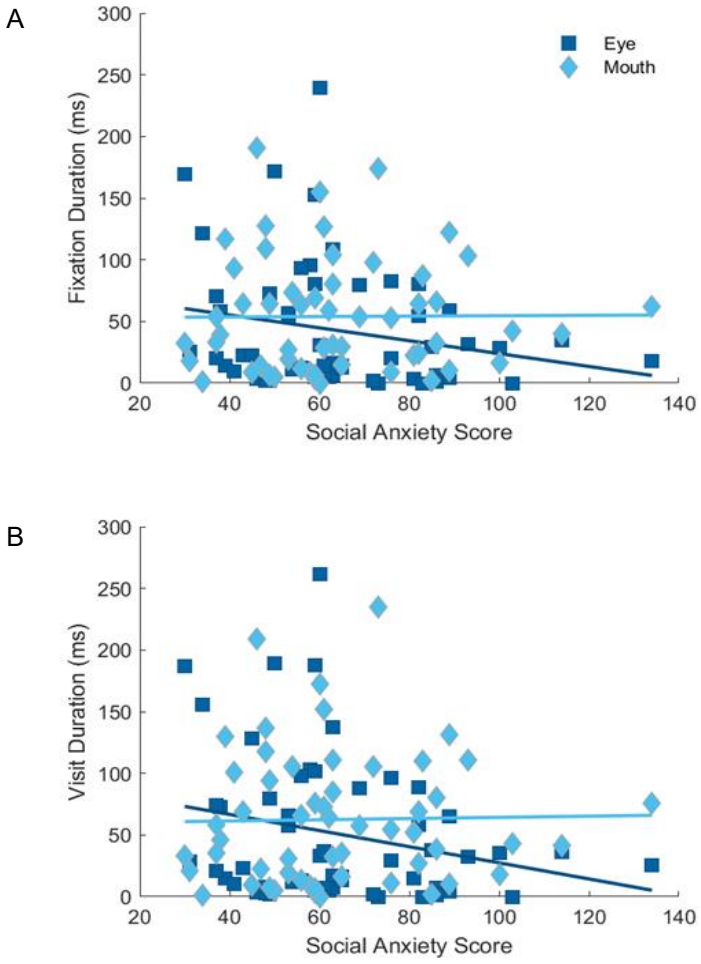


Figure 5. Scatterplots illustrating the correlation between fixation duration (A) and visit duration (B) to the eyes and mouth areas, and participants' social anxiety scores. Each point represents an individual participant, with the x-axis indicating either fixation duration or visit duration, and the y-axis showing the corresponding social anxiety score. A negative correlation is observed for both eye movement measures on the eye area, suggesting that participants with higher social anxiety scores spent less time fixating on and visiting the eyes.

4 DISCUSSION

The current study examined the influence of social anxiety at varying intensity levels on gaze behaviour during virtual communication tasks. Through the analysis of various eye-movement measures within specific AOIs, this study revealed the significant effects of distinct facial regions on the gaze patterns of participants with differing levels of social anxiety. These results align with and expand upon the findings of Chen et al. (2022) who reported a prevalent tendency to avoid the face area in face-to-face interactions among socially anxious individuals. This indicates that these outcomes are widely applicable across various social contexts, including both virtual and face-to-

face settings. Additionally, by focusing on specific facial characteristics, a more detailed understanding of the influence of social anxiety on gaze behaviours was achieved.

Further examination revealed the eyes as a pivotal region that plays a crucial role in the attentional processes of individuals with social anxiety, as indicated by certain eye-movement measures. The main findings can be summarised as follows: (1) individuals with HSA displayed a marginally significant difference, with a notably shorter duration to fixate on the eyes than the mouth; (2) individuals with LSA exhibited a shorter first fixation duration on the eyes than the mouth; and (3) individuals with HSA showed a shorter duration to visit the eyes than the mouth. These results collectively indicate a consistent pattern of reduced engagement with the eyes, including shorter fixation duration, first fixation duration, and visit duration, as compared to other facial regions, such as the mouth, across varying levels of social anxiety. This indicates a tendency for those with social anxiety, irrespective of their level, to exhibit attentional bias, as evidenced by the selective attentional allocation away from the eyes, strongly implying an inclination towards avoidance.

Furthermore, these findings are consistent with those of previous studies on virtual contexts (Hessels et al., 2019; Howell et al., 2015). Despite incorporating additional eye-movement measures, this study found no evidence of rapid initial orientation, a phenomenon commonly reported in previous studies (Rapee & Heimberg, 1997; Rösler et al., 2021). Instead, the data indicated a clear pattern of avoidance towards the eye region, further strengthening the concept of avoidance in individuals with social anxiety.

The avoidance of the eye region observed in individuals with social anxiety may be attributed to informational characteristics associated with the eyes, as it can be a signal of negative emotions such as anger, distress, and disgust or complex mental states like suspicion (Lee & Anderson, 2017). It was also reported that the eyes can be a source of discomfort that can lead to feelings of fear and avoidance (Tönsing et al., 2022). Consequently, these eye characteristics may implicitly convey a sense of threat to individuals with social anxiety. Given the fundamental characteristics of social anxiety, which can include an overwhelming fear of rejection and negative evaluations from others, socially anxious individuals may perceive it as threatening when encountering eyes during interactive tasks, thereby resulting in deliberate avoidance as a protective strategy against potential negative social outcomes (American Psychiatric Association, 2013). Essentially, such avoidance can be understood as a form of safety-seeking behaviour, intended to evade a perceived threat and minimise or prevent the occurrence of feared negative social consequences, while not completely withdrawing from the social situation (Chen et al., 2020). This gaze behavioural pattern is further supported by the cognitive model of social phobia, which proposes that individuals with social anxiety tend to avoid threatening information (Clark & Wells, 1995).

This study further investigated this specific attentional bias and explored the correlation between social anxiety scores and certain eye-movement measures. The findings revealed two key insights: (1) a negative relationship approaching significance, indicating that higher social anxiety levels were associated with shorter durations to fixate on the eyes; and (2) a significant negative relationship, signifying that higher social anxiety levels were linked to shorter durations to visit the eyes. Notably, similar comparisons conducted for the mouth region did not yield any significant correlation. These results highlight an increased sensitivity in individuals with higher

social anxiety, as evidenced by the reduction in duration of both fixations on and visits to the eyes as the level of social anxiety increased. This suggests that the more severe the social anxiety symptoms, the stronger the tendency to demonstrate avoidance, particularly in the eye region. In a systematic review, the author concluded that variations in the Degree of avoidance are correlated with the severity of social anxiety symptoms (Chen et al., 2020). Specifically, it was reported that individuals with clinically diagnosed social anxiety disorder exhibited more pronounced and consistent patterns of gaze avoidance behaviour towards faces than individuals with high social anxiety, but without a formal diagnosis. This distinction emphasises the crucial relationship between the severity of social anxiety symptoms and the extent of avoidance, which is consistent with the outcomes of this study.

One limitation of this study was the use of a pre-recorded video as a stimulus. The restricted participants' interactions with the scripted content within the video, potentially resulting in insufficient capture of the nuances and complexities of real-time social engagements. Notably, discrepancies were observed between the responses provided by the participants and the confederate, leading to confusion among certain participants. To address this limitation, future studies could explore the use of more interactive approaches, such as virtual reality (VR), to create a more immersive and realistic social environment (Lee & Anderson, 2017).

Another limitation of the study is the lack of diversity in the gender and ethnicity of both the participants and the confederate manipulation. This factor may affect interactions and influence social anxiety levels, which, in turn, could impact the gaze behaviours of the participants. Understanding the dynamics of gender and ethnic interactions is crucial for comprehending how social anxiety manifests in different local contexts (Bekker & van Mens-Verhulst, 2007; Tan et al., 2012). Therefore, further studies may consider including these variables to gain a more comprehensive understanding of the dynamics of social anxiety.

Finally, the findings of this study provide a detailed understanding of the intricacies of gaze behaviour within individuals experiencing social anxiety. This contribution has the potential to expand and refine the existing literature within this domain and to provide significant implications for clinical practices and interventions aimed at addressing social anxiety. This knowledge can be utilised to appropriately tailor interventions that specifically target gaze behaviour to facilitate improvements in social interactions among individuals with social anxiety in real-world settings (Matsumoto et al., 2023).

In summary, this present study has provided valuable insights into the gaze behaviour of socially anxious individuals during virtual communication tasks, with particular emphasis on the significance of specific facial regions. The most notable finding was the critical role of the eyes in their impact on the gaze behaviour of these individuals. This was evident in those exhibiting more severe symptoms of social anxiety, where there was pronounced sensitivity and a marked tendency for greater reduction in gaze behaviour, particularly for the eye region. Future research should focus on the eyes as a key feature of social anxiety studies and explore the underlying mechanisms and potential interventions.

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AUTHOR CONTRIBUTIONS

Nurerina Hanizam and Faiz Mustafar conceived and designed the study. Nurerina Hanizam and Faiz Mustafar developed the experimental stimuli, performed the experiment and collected the data. Nurerina Hanizam, Faiz Mustafar and Hafidah Umar conducted the data analysis and interpretation. Faiz Mustafar and Asma Perveen supervised the experiment and contributed to the final version of the manuscript. Asma Perveen, Mohd Zulkifli Mustafa, and Hafidah Umar provided critical feedback on the result and discussion.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest related to this study.

DATA AVAILABILITY STATEMENT

The raw data for this study are available from the corresponding author upon reasonable request.

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