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Role of social competence in emotion processing among emerging adults with anxiety

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Individuals with anxiety disorders tend to gravitate their attention to faces showing anger, which may reinforce fears associated with social situations and impact their social competence. Yet it is unclear whether social competence may explain differences in attention allocation to emotional faces in anxiety disorders. This study used eye-tracking to assess gaze patterns in 57 females aged 15 to 24 who viewed emotional faces (angry and neutral) on a screen. It explored whether latency to first fixation and dwell time on emotional faces (female and male) are dependent on anxiety symptoms and social competence, and if social competence accounts for the association of anxiety with attention allocation. With increasing anxiety symptoms, participants' dwell time on neutral compared to angry female faces increased, yet no effects were observed for male faces. Similarly, with decreasing social competence, participants' dwell time on neutral compared to angry female faces increased, yet no differences were observed for male faces. Contrary to the hypothesis, social competence did not account for the effects of anxiety on attention allocation. No effects were observed for latency to first fixation. Anxiety and social competence are both independently associated with attentional biases toward facial expressions in female participants. Yet, these associations seemed to depend on the gender of the face seen.

Keywords Attentional biases, Social competence, Eye-tracking, Anxiety, Youth

The concept of attention bias to threat among individuals with anxiety suggests that they tend to focus more on threatening stimuli as opposed to neutral stimuli[1]. A substantive body of research has linked threat-related attention biases to anxiety in adults[2,3], whereas extant findings on threat biases in youth are more limited[4]. Yet some research indicates that during emotional perception, anxious youths show similar threat-related attention biases[5].

A particular focus on attention biases in youth may be warranted, as studies have shown that anxiety disorders typically have their onset around the age of 21, with most individuals developing them before turning 25[6,7]. Early onset of anxiety disorders in youth can predispose individuals to other mental health issues such as depression, substance abuse, and suicidal tendencies and increase mortality risk[8–10]. During emerging adulthood, females tend to experience more anxiety symptoms and greater anxiety severity levels than males[11]. Therefore, there is a critical need to prioritize and invest in research that explicitly targets emerging adults (EAs), particularly EA females, to bridge this gap in knowledge and better support the mental health of this vulnerable population. The present study aims to address these limitations by examining threat-related attention biases in EA females using state-of-the-art eye-tracking technology.

Cognitive theory of anxiety disorders

Cognitive theories of anxiety disorders, such as the vigilance-avoidance model, propose that selective attention to negative information is central to anxiety development and persistence[12,13]. This bias involves a preference for attending to negative information and an avoidance of positive cues[12].

Understanding emotion and facial expression processing in anxiety disorders thus requires recognizing the vital role that cognitions, specifically attentional processes, play. Individuals with anxiety disorders tend to avoid neutral faces while gravitating toward negative emotional expressions like fear or anger[14]. Heightened

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vigilance towards perceived threats causes anxious individuals to fixate their attention on potential dangers initially. Over time, cognitive factors like rumination and worry contribute to sustained attentional dwelling on negative information, which perpetuates the cycle of anxiety and exacerbates clinical symptoms. Yet, anxiety may also motivate avoidance of threatening stimuli in an attempt to minimize anxiety exacerbation. Attention biases represent dynamic shifts between the vigilance-avoidance model, particularly in social anxiety[15]. As such, anxiety-related attention control deficits have been observed in inhibition and switching, particularly under high cognitive load conditions[16]. Similarly, individuals with social anxiety often struggle to disengage from threatening cues, notably fixating on angry faces[17]. Bottom-up and top-down processes determine whether an individual exhibits attention avoidance or vigilance. In situations where individuals are prone to anxiety, top-down processes may cause them to avoid threatening stimuli to reduce anxiety (attention avoidance), while in other cases, heightened sensitivity to potential threats may result in increased attention toward such stimuli (attention maintenance). Thus, the interplay between bottom-up and top-down processes significantly shapes our attentional responses, balancing avoidance and vigilance based on external sensory cues and internal cognitive controls[18]. Understanding these cognitive intricacies is crucial for developing targeted interventions that address the diverse cognitive manifestations of anxiety across different populations and contexts.

Eye-tracking studies

Eye-tracking is emerging as a promising avenue for assessing attentional biases due to its potential to provide more direct and reliable information than reaction time across various populations with anxiety[19]. Eye movements are a directly observable characteristic that can describe attentional behaviour. However, the direction of gaze may sometimes be dissociated from the locus of attention. The dot-probe task has historically been a fundamental tool in attention bias assessment. However, recent studies have questioned its reliability, particularly in youth.

Additionally, eye tracking provides high temporal resolution, allowing researchers to precisely capture rapid shifts in attentional focus[20]. This temporal granularity is particularly advantageous for studying attention biases, which often involve rapid and automatic processes. Overall, eye-tracking's practicality, affordability, portability, and ecological validity make it a valuable tool for investigating attention biases in anxiety across diverse populations and settings.

Consequently, researchers have utilized eye-tracking to examine cognition in anxiety such as emotional face processing (negative and neutral facial stimuli), revealing intricate patterns of attention and gaze behavior. Studies have highlighted both avoidance behaviors and heightened vigilance toward certain facial features, especially the eyes, among individuals with social anxiety[21,22]. Some studies have found evidence for hypervigilance toward threat-related facial cues, while others have reported avoidance of such cues[23], increased maintenance[24] or no significant differences between anxious and non-anxious youth peers[25,26]. Adding further complexity, research has also identified restricted eye-scanning patterns in youth with social anxiety, suggesting difficulties in holistic face processing[21,27–29]. Moreover, findings point to challenges in emotion identification, particularly when facial expressions are ambiguous or partially obscured[29]. Finally, other work has provided insights into attentional control deficits in social anxiety, especially in the context of emotional ambiguity[14]. Collectively, these studies show the utility of adopting eye-tracking methodologies in unravelling the complexities of emotional processing and attentional mechanisms in anxiety disorders.

A recent review and meta-analysis Clauss, Gorday and Bardeen[19] examined the relationship between anxiety- and fear-related symptoms and threat-related attentional bias using eye-tracking technology among adults (18 and older). The meta-analysis included 40 studies involving 1,815 participants, predominantly involving non-clinical samples (77.2%) and self-reported measures of anxiety. Effect sizes were calculated using Pearson correlation coefficients, with positive values indicating a greater bias towards threat stimuli. The analysis revealed significant associations between anxiety-related symptoms and threat-related attentional bias. Reflexive orienting, measured by the proportion of first fixations on threat and latency to first fixation, showed a small, positive correlation effect with anxiety (r = .13, 95% CI: 0.03, 0.22). Maintenance of attention to threat, assessed by the proportion of dwell time on threat versus neutral stimuli also exhibited a small, positive correlation with anxiety (r = .15, 95% CI: 0.05, 0.25). These findings suggest that individuals with anxiety- and fear-related symptoms exhibit a threat-related attentional bias when assessed through eye-tracking tasks.

Conversely, another systematic review and meta-analysis of eye tracking studies for attentional bias to threat in children and adolescents (18 and younger) reported a contrary finding[30]. They drew insights from 13 eligible studies encompassing 798 participants aged 3 to 18 years old, including clinical samples (n = 540) and analog samples (n = 258). The analysis meticulously categorized participants into anxious youth and non-anxious controls. Employing stringent inclusion criteria, the researchers began a comprehensive exploration, utilizing eye-tracking methodology alongside standardized anxiety assessment tools. Contrary to expectations, the overall results indicated that neither anxious nor non-anxious youth exhibited an initial bias towards threat (g = − 0.04). However, differences emerged in dwell time, with anxious youth being more avoidant of threat throughout the stimulus viewing period, as shown by a lower overall fixation duration on threat stimuli (g = − 0.26). This novel insight shows a pivotal shift in understanding attentional mechanisms in anxiety, shedding light on the complex interplay between attentional vigilance and avoidance behaviors over the transition from childhood/adolescence to adulthood. Notably, the study emphasizes the developmental disparities within neural circuits governing attentional deployment towards emotional stimuli, thereby accentuating the need for tailored assessment approaches that accommodate these variations.

Interestingly, the results of these two meta-analyses seem to reflect the two seemingly contradictory models of threat-related attention biases: the attention maintenance and vigilance-avoidance models[31,32]. The attention maintenance model suggests that individuals with anxiety disorders do not exhibit a reflexive orientation toward the threat. Still, once they detect the threat, they have difficulty disengaging from the threat (i.e., maintenance). In contrast, the vigilance-avoidance model suggests that following the initial rapid orientation toward the threat,

individuals with anxiety disorders experience emotional and physiological arousal. In response, the individual may attempt to cope with this emotional distress, often via maladaptive avoidance. Specifically, while the individual's emotional distress may be reduced in the short term by avoidance, the anxiety symptoms will be maintained and exacerbated over more extended periods[33].

The discrepancies between the two recent meta-analyses[19,30] and the two models stress the complexity of attentional mechanisms in anxiety, especially in emerging adults, who fall between the age ranges included in the two contrasting meta-analyses. These divergent results emphasize the importance of replicating the studies to better understand the dynamics of avoidance behaviors alongside vigilance in young individuals with anxiety. By elucidating these dynamics through eye-tracking, this current study aims to explore the mechanism of attention bias in emerging adults. The use of eye-tracking technology can provide crucial insights into the cognitive underpinnings of anxiety, subsequently aiding in the development of more effective interventions and treatments.

Gender, social competence, and attentional bias in anxiety

Two factors, among many others, additionally come into play when assessing heterogeneity in studies examining attentional biases in individuals with anxiety. Firstly, there may be distinctive responses depending on the gender of the facial stimuli[34]. Specifically, an event-related brain potentials (ERPs) study has revealed that individuals with social anxiety disorder (SAD) exhibit a diminished late positive potential in response to male faces, a pattern contrary to what is observed in healthy and clinical control groups[15]. This heightened arousal to male faces, particularly that related to threat perception, has attracted the attention of researchers assessing attention biases. Peschard et al. (2019)[36] decided to use only male faces, building on previous research that demonstrated these stimuli elicit stronger emotional responses than female faces. Studies by [37] found that male faces and bodies, when expressing emotions such as anger and fear, are more likely to provoke heightened arousal. This pattern suggests that male stimuli may be perceived as more threatening, making them particularly suitable for investigating the dynamics of attention bias. This implies that the gender of facial stimuli could be a primary factor influencing differences in attention allocation among anxious emerging adults.

Second, there has been insufficient study of the effect of social competence on responses to facial stimuli processing. Social competence refers to a broad set of abilities that enable individuals to effectively navigate social situations, including interpreting social cues, regulating emotions, and engaging in prosocial behavior. It is closely intertwined with the development and maintenance of interpersonal relationships and plays a significant role in anxiety[37]. Indeed, individuals with lower perceived social competence may experience more severe anxiety[38], especially in social situations. Notably, developmental studies have shown that difficulties in social competence—such as peer victimization and poor friendship quality—can predict the onset and persistence of social anxiety, particularly in childhood and adolescence[39]. These findings underscore the relevance of social competence as a potential early marker and maintaining factor for anxiety-related disorders[39]. Social competence has been suggested to play a role in attention biases[40] but has never formally been studied in anxiety-related attentional processes. Yet, individuals with lower perceived social competence may be more likely to misinterpret neutral or ambiguous facial expressions as threatening, contributing to heightened attentional biases and maladaptive avoidance behaviours during social interactions[41].

Overall, the relationship between social competence and anxiety is further complicated by the influence of gender[42]. Despite the empirical support for several factors influencing the avoidance of neutral faces and the attraction to angry expressions, a notable gap exists in the literature regarding a more detailed investigation of the gender of both facial stimuli and the perceiver[43] and the role of social competence in contributing to this dynamic[44]. This gap highlights an important area for exploring anxiety-related biases in facial expression processing.

The current study aimed to advance the current literature by exploring differences in attention biases concerning social competence and the gender of emotional faces seen among female emerging adults (a population at elevated risk of anxiety). Building on the recent meta-analysis including younger participants[19,30], we hypothesized that (1) emerging adult females with higher anxiety symptoms would dwell shorter on angry vs. neutral faces, and this bias would be more pronounced for male faces, (2) those with lower social competence would display more anxiety symptoms, (3) poorer social competence would be associated with a shorter dwell time on angry vs. neutral faces, and 4) social competence would account for the association of anxiety and longer dwell time on angry faces. No effects were expected for latency to first fixation. This research has the potential not only to refine theoretical models of anxiety-related biases but also to inform clinical practices aimed at alleviating the social challenges faced by females with anxiety disorders.

Methods

Participants

The present study included 57 female emerging adults aged 15 to 24[45]. Data collection commenced in October 2022 and concluded in April 2023. Ethics approval was obtained from the IWK Research Ethics Board (#1027338). All research involving human participants was conducted in accordance with the ethical standards outlined in the Declaration of Helsinki and the institutional guidelines and regulations. We confirm that all methods were carried out in compliance with these guidelines. Informed consent was obtained from participants that are minors prior to participation in the study. No participant commenced any study-related procedures until parental or guardian consent was documented. Inclusion criteria were that the respondent be English speaking, 15–24 years of age, female at birth, and have no severe visual impairments that might impact eye-tracking data. The deliberate selection of females aligns with their more severe clinical presentation of anxiety disorders compared to males[46]. The age range was intentionally restricted to focus on emerging adults as they represent the transition between adolescence and adulthood, where different theories/patterns of attentional bias appear to operate[4]. Participants

accessed screening questions and a consent form electronically through the Research Data Capture (REDCap) platform. Following the electronic signing of the consent form, eligible participants completed questionnaires on anxiety, social competence, and demographics on REDCap. Subsequently, participants attended an in-person study visit at the Izaak Walton Killam Hospital (IWK) for eye-tracking assessments. Participants were recruited through various sources, including the Dalhousie University Department of Psychology and Neuroscience's undergraduate database and other online and print advertisements. Participants received a small honorarium for their time investment.

Participant characteristics appear in Table 1. The sample consisted of 57 participants, all of whom were female, with 98% identifying as women. The average age of the participants was 20.36 years, with a standard deviation of 1.75 years. Ethnically, the majority were Caucasian (70.2%), followed by Asian (15.8%), Black or African Descent (7.0%), Hispanic or Latino (1.7%), and Indigenous (5.3%). Regarding mental health, 61% of the participants had been diagnosed with a mental health condition by a professional, 30% with an anxiety disorder, 23% with depression, 12% with attention deficit hyperactivity disorder, Additionally, participants' average anxiety score on the SCARED was 42.93, with a standard deviation of 15.77.

Measures

Anxiety symptoms were assessed using the Screen for Child Anxiety-Related Emotional Disorders (SCARED) and Screen for Adult Anxiety Related Disorders (SCAARED). These assessment tools cover a broad spectrum of anxiety symptoms. The SCARED consists of 41 questions designed for adolescents between 8 and 18 years old. The SCARED is rated on a 3-point scale (0, 1, or 2), providing scores for various anxiety subtypes such as Panic Disorder, Generalized Anxiety, Separation Anxiety, Social Anxiety, and School Avoidance, alongside an overall Total Score. This questionnaire demonstrates satisfactory internal consistency (α = 0.91–0.92 for subscales; α = 0.97 for total score) and test-retest reliability (r = .782)[47–49]. The SCAARED, a 44-item questionnaire, was used for participants who reported their age as 19–25. The SCAARED is a modified version of the SCARED designed to assess anxiety symptoms in emerging adults between 19 and 25 years old. The SCAARED consists of the same five subscales as seen in the SCARED questionnaire, with each item rated on the same 3-point scale as the SCARED. These subscales include Panic Disorder, Generalized Anxiety, Separation Anxiety, and Social Anxiety, alongside an overall Total Score. Given the differing number of items, the total score on the SCARED and SCAARED can range from 0 to 82 and 0 to 88, respectively. Thus, the SCARED scores were divided by 41 (the number of items) and then multiplied by 44 (the number of SCAARED items) to put the scores into a standard metric. An anxiety score greater than 23 or 25 indicates clinically significant anxiety using SCARED and SCAARED, respectively. 52 out of 57 participants (91.23%) had scores between 23 and 78, indicating clinically significant anxiety.

A shortened version of the Interpersonal Competence Questionnaire (ICQ-15) was used to assess social competence. To decrease time commitment, as well as feelings of boredom and fatigue that are typically associated with long questionnaires, the ICQ-15 was specifically chosen over the original ICQ[50–52]. The ICQ-15 includes 15 items on a 4-point Likert scale ranging from 1 to 4[53,54]. The scale measures five 3-item subscales of social competence: (1) conflict management, (2) initiating relationships, (3) negative assertion, (4) self-disclosure of personal information, and (5) providing emotional support[53–55]. The ICQ-15 has been shown to have satisfactory internal consistency reliability for the total score (α = 0.87), as well as the subscales (α = 0.61–0.75)[55].

Eye tracking apparatus

Our eye-tracking assessments utilized the Eye-Link 1000 +, a monocular, remote eye-tracking system with a 25 mm lens. This apparatus recorded gaze data, primarily from the right eye, unless obstructed. The Eye-Link 1000 + is an eye-tracking system (SR Research, Ontario, Canada) that uses a sampling rate of 500 Hz and a gaze position accuracy of 0.5°. This eye tracker can compensate for changes in head position; therefore, no head-resting device was required. Participants were approximately 60 cm from the eye-tracking equipment, and a

Parameters	*N* (57)	Mean	SD
Sex (Male, Female)		100% Female	
Gender (Men, Women, Non-Binary)		98% Women	
Age (in years)		20.36	1.75
Ethnicity			
Caucasian	40		
Asian	9		
Black or African American	4		
Hispanic / Latino	1		
Indigenous	3		
Mental Health diagnosed by Professional		61%	
Anxiety (Score)		42.93	15.77

Table 1. Participant characteristics. Note: The data in the table provides the demographic details, gender distribution, ethnicity, age, mental health diagnoses, and anxiety scores for the study participants (N = 57).



Fig. 1. Screen content with initial fixation dot.



Fig. 2. Screen Content with initial fixation dot and defined AOIs. The Faces were cropped to a circular shape to minimize extraneous visual information, ensuring that attention is focused solely on facial features and expressions for precise analysis of gaze patterns.

target sticker was placed between their eyebrows. The Eye-Link 1000 + camera was located below the display screen, and a 9-point calibration was performed before each session.

Stimuli

Stimuli for the eye-tracking assessments comprised static photos of 10 human faces, including five female and five male faces, each displaying two emotional expressions (angry, neutral). These images were sourced from the Karolinska Directed Emotional Faces (KEDF) collection, which is known for its validity and reliability[56]. The KEDF stimuli were chosen above other facial emotion stimulus sets given the appropriateness of the age of the models; specifically, the amateur models' ages ranged from 20 to 30 years old[57]. In the stimulus presentation, participants were first presented with a start screen containing a fixation dot, prompting them to fixate their gaze. Following the fixation dot, two emotional facial expressions (angry and neutral) of male and female models were displayed randomly on either the left or right side of the screen, based on the block assigned to each participant (Fig. 1). The total number of trials was 20, where each stimulus appeared for 4 s, with an equal distribution of angry and neutral expression stimuli for both model genders. We used single-face trials to isolate attention without competing stimuli, allowing clearer interpretation of engagement or avoidance. Emotional stimuli presented in a single modality have been shown to sufficiently engage attention, as evidenced by increased late positive component (LPC) activity[58]. The large size of the face stimuli further ensured that disengagement from the image indicated attentional avoidance rather than distraction by peripheral content.

Data processing

Eye movement data were recorded using the EyeLink 1000 + desktop-mounted system (SR Research Ltd., Ontario, Canada), a video-based eye tracker that samples gaze data at 1000 Hz and provides digital gaze coordinates. Participants were seated approximately 60 cm from a 23-inch monitor in a moderately lit room. Binocular tracking was conducted, and data from the dominant eye were analyzed. A standard 9-point calibration and validation procedure was performed before each task. Then, it compared where the participants looked with where the tracker thinks they looked. If the difference exceeds the default angle of the valid calibration by the eye tracking device, next it marked the calibration as poor or invalid. This helped to make sure the data is reliable before starting the experiment.

The maintained calibration accuracy was below 0.5° of visual angle; recalibration was conducted if drift exceeded 1° during recording. Stimuli were presented using a custom Python script that controlled image presentation, trial structure, and time-locked stimulus onset. All trial and bounding box data were parsed and analyzed using a structured R script that imported participant-level trial information, image metadata (e.g., emotion, gender, location), and region-of-interest bounds (the face, see Fig. 2). Given the aims of the current study, we focused solely on visual attention directed towards the oval face region for angry and neutral face expression, which were defined as the areas of interest (AOIs).

Fixations were classified using the EyeLink's built-in event parser, which applies a dispersion-based algorithm (I-DT) with a minimum fixation duration threshold of 100 ms and a spatial dispersion threshold of 0.5° of visual

angle. Fixations shorter than 100 ms were discarded to reduce the inclusion of artifacts, and no post hoc merging of adjacent fixations was applied to preserve the integrity of micro-shifts in gaze. Gaze data were mapped to screen pixel coordinates. All 57 participants had valid fixation time data of at least 100 milliseconds. During preprocessing using a custom Python script, fixations were further filtered to exclude periods affected by blinks or tracking loss and were matched to trial-level metadata using participant IDs and block numbers. However, 21 trials were excluded because participants had already fixated on the stimulus area before its actual appearance, making it impossible to calculate a valid fixation time. This resulted in a total of 1,119 trials included in the analyses. These preprocessing procedures followed current reporting standards to ensure data quality and timing precision in latency and dwell-time analyses[59,60].

Data analysis

All statistical analyses were completed using the R programming language (version 4.2.2) and RStudio (version 2022.07.02 Build 576)[61]. Descriptive statistics were calculated for the sample, including demographic information. Data were analyzed using linear mixed-effects models with random intercepts for individuals (equal to treating multiple observations from the same individual as repeated measures), as linear mixed-effects models are more robust to type I and type II errors than traditional analyses of variance (ANOVAs) in experimental data with multiple trials per individual[62]. To ensure high data quality, we implemented a customized preprocessing pipeline in Python that systematically identified and flagged participants with calibration issues or deviations from the expected number of trials. Eye-tracking data were examined to confirm that each participant completed the task with a near-complete dataset i.e., had valid fixation data on 1,140 trials across 57 participants. Specifically, gaze data were screened to identify and exclude 21 trials where participants fixated on the stimulus area before its actual appearance. This quality control process minimized the risk of inaccurate dwell time estimates due to invalid or incomplete recordings. To assess the first hypothesis, we ran a set of two linear mixed-effects models with dwell time as the respective outcomes of interest and the emotion of the face seen (i.e., angry or neutral), the gender of the face (i.e., male or female), and anxiety scores as the predictors. Predictors were entered into the models in three steps: (a) the main effects of anxiety symptoms, facial emotion, and gender of the face; (b) the two-way interactions; and (c) the three-way interaction. To assess the association of anxiety symptoms with social competence (hypothesis 2), we fitted a linear regression model with anxiety symptoms as the predictor and social competence as the outcome of interest. To address hypothesis 3, we first ran a linear mixed-effects model to establish the effect of social competence, with dwell time as the outcome of interest and social competence score (continuous measure), emotion, and gender of the face as the predictors. Next, we ran a linear mixed model adding the predictors (a) anxiety symptoms, social competence, facial emotion, and gender of the face; (b) the two-way interactions; and (c) the three-way interaction. In the final step of testing hypothesis 4, we compared this model, combining anxiety symptoms and social competence as predictors, to the model developed for hypothesis 1, which focused on anxiety symptoms using likelihood ratio tests. To test whether participants showed no initial vigilance in line with the attention maintenance model, analyses were repeated with latency to the first fixation as the outcome. The location of the face and trial number were included as covariates in all models. Given the small age range, we did not account for age.

Results

Anxiety and dwell time

There was a significant three-way interaction between anxiety symptoms, facial emotion, and gender of the face observed for dwell time (beta = -0.25, 95% CI [-0.46, -0.05], t(1074) = -2.40, $p = .02$). The two-way interaction of anxiety and emotion of the face (beta = 0.19, 95% CI [0.05, 0.34], t(1074) = 2.63, $p = .01$) was also found to be significant, while the other two-way interactions were not significant. As displayed in Fig. 3, at low levels of anxiety symptoms, participants dwelt more on neutral than angry male faces, but this bias disappeared at high levels of anxiety symptoms. In contrast, at low levels of anxiety symptoms, participants dwelt longer on angry than neutral female faces. Still, this tendency switched to greater dwell time on neutral than angry female faces as anxiety symptoms increased. Stratified by gender of the face, the two-way interaction between anxiety symptoms and facial emotion was only significant for female faces (beta = 0.20, 95% CI [0.05, 0.35], t (509) = 2.66, $p = .01$). Finally, the only significant main effect was observed for the location of the face (beta = -0.11, 95% CI [-0.21, -0.01], t (1074) =- 2.09, $p = .04$): emerging adult females dwelt longer on faces displayed on the right side compared to the left side of the screen.

Anxiety and social competence

There was a strong main effect observed for anxiety symptoms on social competence (beta = -0.41, 95% CI [-0.66, -0.16], t(55) = -3.32, $p = .002$): emerging adults displayed significantly less social competence with increasing anxiety symptoms. The scatter plot in Fig. 4 illustrates a clear inverse relationship between anxiety symptoms and social competence among emerging adults. Each point represents an individual's scores, showing that higher anxiety is associated with lower social competence. The downward-sloping blue regression line, with its shaded confidence interval, confirms this trend.

Social competence and dwell time

The three-way interaction between social competence, emotion, and gender of the face was significant for dwell time (beta = 0.27, 95% CI [0.07, 0.48], t(1074) = 2.60, $p = .01$). 48], t(1074) = 2.59, $p = .01$). The only significant two-way interaction was observed for social competence and emotion of the face (beta = -0.19, 95% CI [-0.33, -0.04], t(1074) = -2.54, $p = .01$). As displayed in Fig. 5 emerging adult females dwelt longer on angry than neutral male faces at low levels of social competence but dwelt longer on neutral than angry male faces at high levels

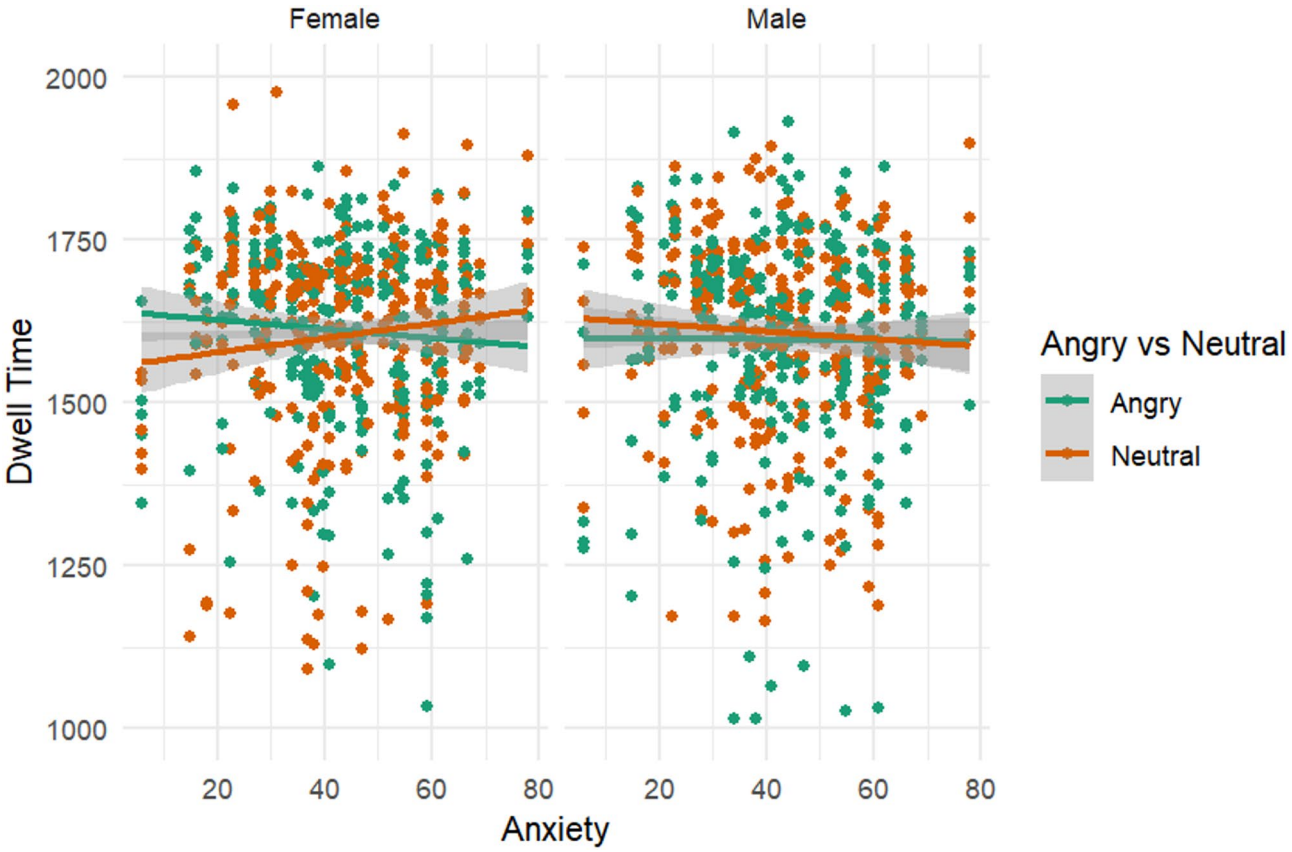


Fig. 3. Dwell time by anxiety symptoms, emotion of the face, and stimulus gender.

of social competence. In contrast, they dwelt longer on neutral than angry female faces at lower levels of social competence but dwelt longer on angry than neutral female faces at high levels of social competence. Stratified by gender of the face, the two-way interaction between social competence and facial emotion was only significant for female faces (beta = -0.19, 95% CI [-0.34, -0.05], t(509) =-2.58, $p = .01$). Finally, the main effect for the location of the face (beta = -0.10, 95% CI [-0.21, -0.00], t(1074) = -1.96, $p < .05$) was again significant while all the other main effects were not.

Anxiety, social competence, and dwell time

Model comparisons revealed that adding social competence to the model, including the triple interaction of anxiety, emotion, and gender of the face did not improve the model $\chi 2$ (2) = 2.95, $p = .23$). Moreover, the three-way interaction between anxiety, emotion, and gender of the face was significant for dwell time (beta = -0.25, 95% CI [-0.46, -0.05], t(1074) = -2.39, $p = .02$) persisted after adjusting for social competence. Interestingly, the three-way interaction on dwell time between social competence, emotion, and gender of the face similarly persisted after adjusting for anxiety (beta = 0.27, 95% CI [0.07, 0.48], t(1074) = -1.99, $p = .047$).

Anxiety, social competence, and first fixation

The latency to first fixation analysis is depicted in Fig. 6, showing that anxiety (beta = -0.010, 95% CI [-0.24, 0.05], $p = .19$) had a non-significant effect, as did emotion (beta = -0.08, 95% CI [-0.24, 0.08], $p = .05$), gender (beta = -0.17, 95% CI [-0.33, 0.00], $p = .23$) and image location (beta = 0.06, 95% CI [-0.05, 0.17], $p = .31$). Interactions between anxiety and emotion (beta = -0.00, 95% CI [-0.16, 0.15], $p = .32$, anxiety and gender (beta = -0.08, 95% CI [-0.23, 0.07], $p = .99$) were non-significant, as were interactions between emotion and gender (beta = -0.00, 95% CI [-0.24, 0.23], $p = .97$) and the three-way interaction (beta = 0.09, 95% CI [-0.13, 0.31], $p = .42$).

Social competence had no significant effect on latency to first fixation (beta = 0.00, 95% CI [-0.14, 0.15], $p = .97$). The effects of emotion (beta = -0.08, 95% CI [-0.24, 0.08], $p = .05$), gender (beta = -0.17, 95% CI [-0.33, 0.00], $p = .23$) and image location (beta = 0.06, 95% CI [-0.05, 0.17], $p = .15$) were non-significant (Fig. 7). The interactions between social competence and emotion (beta = 0.03, 95% CI [-0.12, 0.18], $p = .31$), social competence and gender (beta = 0.11, 95% CI [-0.04, 0.27], $p = .71$) were non-significant, as were interactions between emotion and gender (beta = -0.00, 95% CI [-0.24, 0.23], $p = .97$) and the three-way interaction (beta = -0.11, 95% CI [-0.33, 0.10], $p = .31$) were non-significant as well.

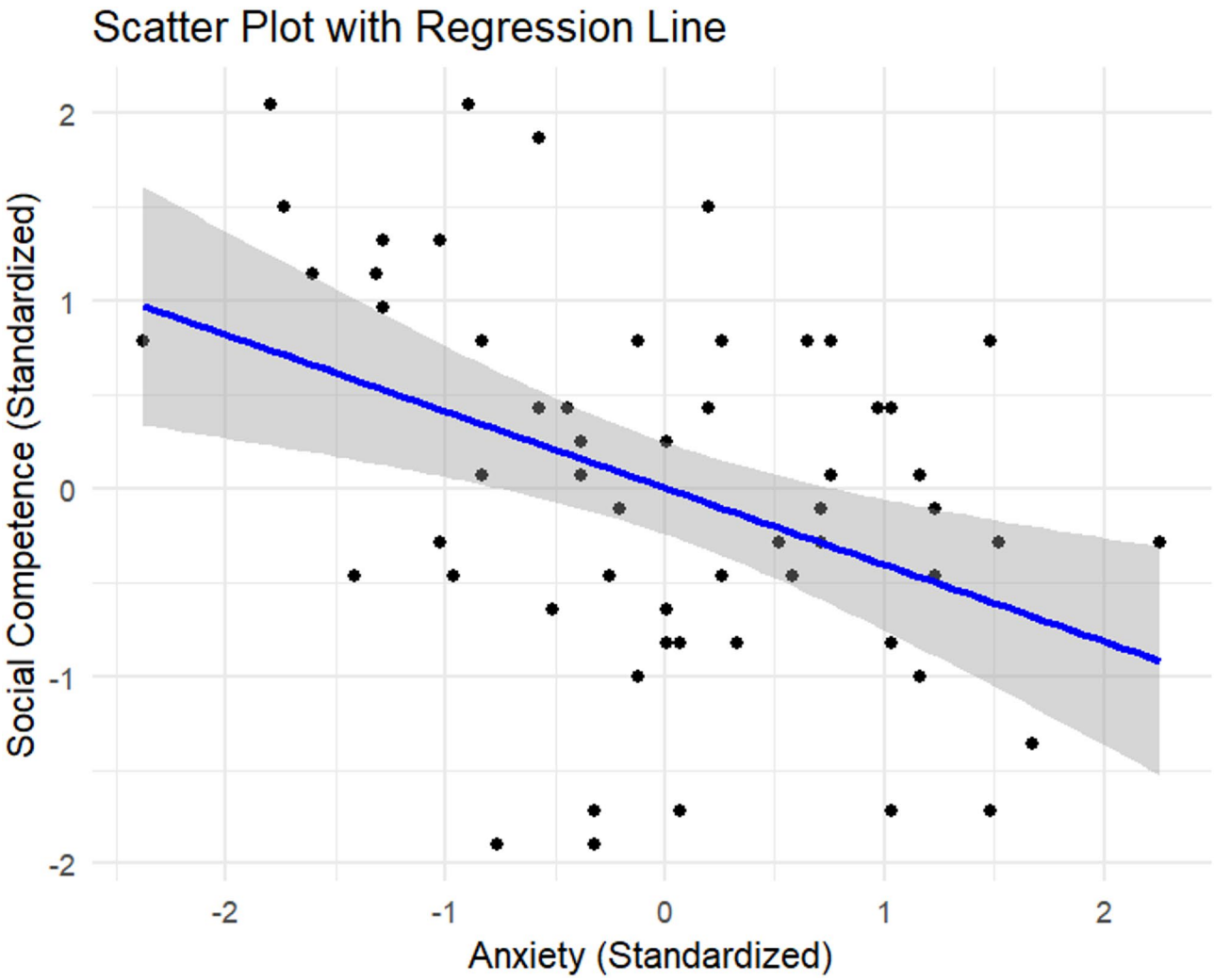


Fig. 4. Negative relationship between anxiety symptoms and social competence.

Discussion

The current study employed eye-tracking technology to examine how anxious female emerging adults (aged 15 to 24) allocate visual attention to angry vs. neutral faces. Specifically, the present study explored whether emerging adult females experiencing higher levels of anxiety tend to gaze longer at angry than neutral faces, particularly considering the gender of the face. Additionally, it sought to investigate whether emerging adult females with poor social competence tend to experience elevated levels of anxiety and if this is associated with attention bias towards angry vs. neutral expressions. Overall, findings showed that emerging adult females with higher anxiety symptoms dwelt less on angry than neutral female faces and tended to dwell longer on angry versus neutral male faces. Higher anxiety was strongly linked to lower social competence. Emerging adult females with poor social competence similarly dwelt less on angry than neutral female faces but tended to dwell longer on angry than neutral male faces. Yet, interactive effects were only significant for female faces. While low social competence showed a similar pattern of attention bias as high anxiety, social competence did not account for the association between anxiety and differential dwell time on angry vs. neutral female faces. Similarly, anxiety did not account for the association between social competence and differential dwell time on angry vs. neutral female faces. No effects of anxiety or social competence were observed for latency to first fixation.

The result of the current study partially aligns with cognitive theories of anxiety disorders, which propose that selective attention to negative information is central to anxiety development and persistence[63,64]. As hypothesized, our findings on same-sex female faces resulting in significantly longer dwell time on neutral faces align best with the avoidance component of the vigilance-avoidance model[31]. In line with Lisk, et al.[30] findings on anxious children and adolescents, emerging adults showed an avoidance bias towards threat stimuli and spent less overall dwell time on these compared to neutral stimuli. In contrast, the current study failed to observe attention biases consistent with the maintenance model described in the meta-analysis of adults Clauss et al.[19] or only at a non-significant trend level when participants observed opposite-sex male faces. The null findings regarding the latency to first fixation are consistent with our a priori hypotheses and align with the meta-analysis of youth[30], which similarly reported no effects. These findings do, however, contrast with the meta-analysis of



Fig. 5. Dwell time and social competence emotion of the face, and stimulus gender.

adults Clauss et al.[19], in which anxiety symptoms were associated with a shorter latency to the first fixation on threat stimuli. Thus, the current study partially supports the attention maintenance and avoidance models[32] in line with previous research, similarly indicating that observed attention mechanisms can't solely be explained by one of these models[19,30].

The findings further indicate that, in addition to the developmental stage of the observer, the gender of the face seen might explain observed differences in attention biases. The gender-specific response adds a layer of complexity, indicating that the type of threat (male vs. female) may differentially affect attention allocation and should be considered in developing interventions. This is also not the first study indicating that both theoretical models could be at play in anxiety attention allocation. Wieckowski, et al.[65] highlighted the variability in attention biases among socially anxious adolescents, showing both vigilance and avoidance depending on various factors. One of these factors is the gender of the stimuli displayed; angry male faces have been documented to be perceived as more threatening and to elicit higher arousal, which may explain the observed differences[35,36]. For example, the high arousal in relation to male faces could have nullified the avoidance behaviour shown towards female faces resulting in no observable differences for male faces.

In terms of social competence, the study found that emerging adult females with lower social competence showed the same pattern of attention toward facial emotions seen in individuals with higher anxiety symptoms. In contrast, those with higher social competence showed the opposite pattern. This partially aligns with research suggesting that higher social competence is associated with better processing and interpretation of social cues, such as facial expressions. For instance, it demonstrated that improving social skills and confidence can enhance social competence. This is consistent with the observation that those with higher social competence might be more attentive to emotional expressions, such as anger. However, the present study also found that social competence did not explain the association of anxiety symptoms with dwell time, nor did anxiety explain the effects of social competence on attention allocation. In other words, while social competence and anxiety independently influence how individuals process social stimuli, they do not interplay in a way that one accounts for the effect of the other on dwell time. This finding is consistent with[66,67], who discuss how social anxiety and poor peer relationships independently impair social competence and social functioning. Thus, while higher

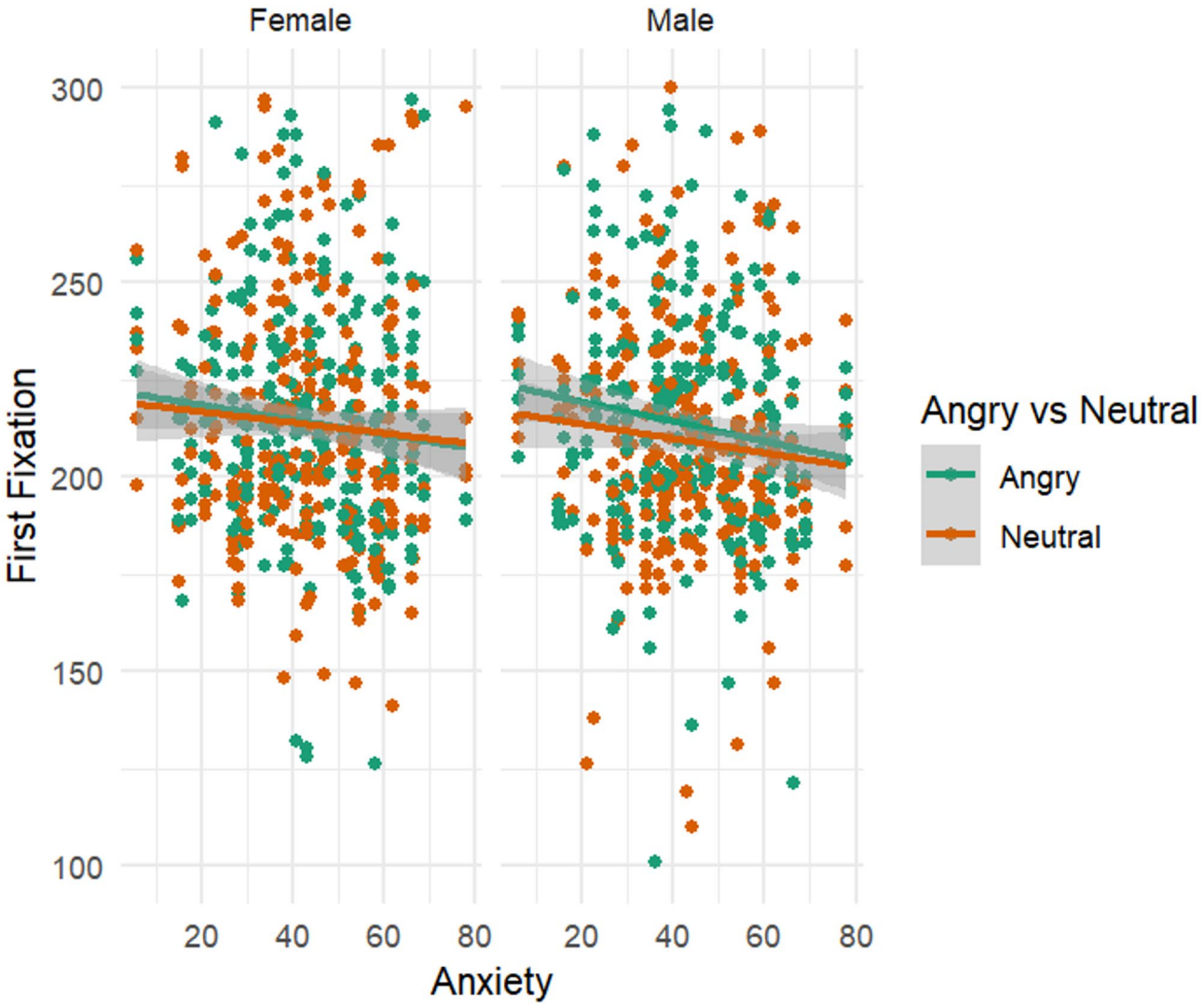


Fig. 6. Latency to first fixation by anxiety symptoms, the emotion of the face, and stimulus gender.

social competence may enhance attention to certain emotional expressions, it does not mitigate the impact of anxiety on how long emerging adult females dwell on these expressions.

The current study found that both anxiety symptoms and social competence independently influenced attention allocation to emotional faces in emerging adult females. Participants with higher anxiety or lower social competence showed increased dwell time on neutral over angry female faces, suggesting disengagement from socially threatening cues. In contrast, individuals with higher social competence spent more time attending to angry faces, indicating possible adaptive engagement with emotional signals. Notably, these effects were not observed for male faces, suggesting that the gender of the face modulated attentional bias. Moreover, anxiety and social competence did not mediate each other's effects, indicating that both traits uniquely contribute to how emotional information is processed. This aligns with previous findings that social anxiety and poor peer relationships can independently impair social competence and social functioning[68].

These findings add to the complex literature on attentional bias in youth, where prior studies have shown mixed results, some reporting bias toward threat in anxious adolescents and young adults[68,69], while others report no significant differences[70]. Neuroimaging studies also suggest that adolescents with threat avoidance show reduced activity to angry and neutral faces in early visual processing regions[71]. This study contributes a more sensitive understanding of how emerging adults allocate sustained attention to emotional cues by focusing on dwell time. These findings show the importance of considering both anxiety and social competence factors and the gender of facial stimuli when interpreting attentional patterns during this critical developmental stage.

Overall, the findings from the current study support existing theories and research on attentional biases in anxiety, while also providing new insights into the complexities of these biases through the lens of dwell time metrics. By highlighting the role of gender of face in moderating anxiety's effect on the maintenance of spatial attention toward emotional expressions on faces, the study enriches our understanding of how anxiety affects visual attention and points toward the necessity for more nuanced research in this area.

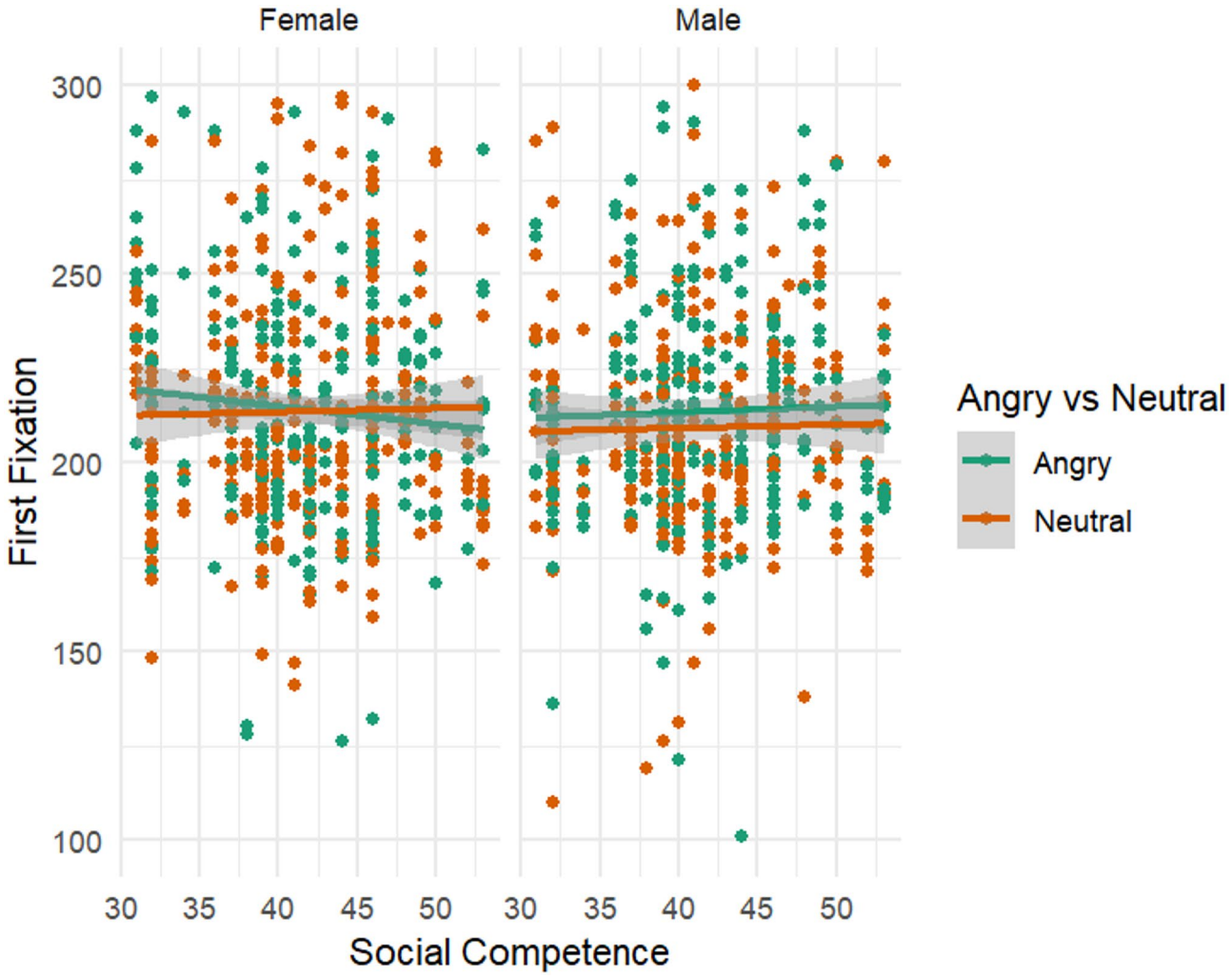


Fig. 7. Latency to first fixation as a function of social competence, emotion of the face, and stimulus gender.

Limitations

Despite the significant contributions of the current study, several limitations limit the generalizability of the results. These limitations include the sample composition, ethnic diversity, and measurement methodology.

Firstly, understanding the link between anxiety and social competence in female participants only provides exclusive findings peculiar to females, as they tend to exhibit anxiety more than males[11]. Yet, these findings may not be generalized to male populations. Gender differences in attentional processes have been well-documented, suggesting that attentional biases may vary between males and females due to biological and socio-cultural factors[72]. While the choice to focus on female participants was made to reduce heterogeneity within the study sample, this approach limits our understanding of attentional processes involving social threat in males. We also acknowledge that including a participant whose gender identity differed from their biological sex may introduce slight variability. Focusing on participants' gender rather than biological sex may limit interpretation, as sex-related biological differences, such as hormonal factors, could subtly influence gaze patterns and facial processing, potentially affecting the generalizability of our results. Similarly, the small number of face stimuli used may introduce stimulus-specific effects. Future studies should aim to include a balanced sex representation of participants to provide a more comprehensive understanding of attentional biases in emerging adults and use a more diverse set of faces. Moreover, it is important to interpret the findings on social competence in light of the potential overlap between social competence and related constructs, including emotional regulation, executive functioning, and theory of mind. These traits are often interrelated and may confound the unique effects of social competence on socio-emotional processing. Future research should thus continue to disentangle these constructs to clarify their independent contributions.

Secondly, the predominance of Caucasian individuals in the study sample raises concerns about the generalizability of findings to more ethnically diverse populations. Ethnicity plays a significant role in shaping individuals' experiences and responses to anxiety[73]. Therefore, the lack of ethnic diversity in the sample may limit the applicability of the findings to individuals from different ethnic backgrounds. Moreover, attentional biases may vary across ethnic groups due to cultural differences in attentional processing and threat[74]. The

complexities of attentional biases across diverse ethnic groups explain the need for more inclusive sampling strategies in future research.

Finally, we used peer faces in our study, and it's important to note that attentional biases may vary when considering older adult faces. Peer faces can introduce specific dynamics that may not generalize to stimuli representing other age groups. Understanding these variations is crucial for developing targeted interventions, such as ABMT[75], which aims to modify biased attentional patterns implicated in various psychological disorders. Future research should explore these differences and consider enhancing the validity and reliability of findings to inform effective clinical interventions.

Conclusion

The current study reveals relevant insights into attentional biases among emerging adults, highlighting that increased anxiety symptoms are associated with decreased dwell times on angry female faces and nearly no change in dwell times on angry male faces. The findings also indicate a significant relationship between anxiety symptoms and reduced social competence. Interestingly, while lower social competence (like higher anxiety) was associated with shorter dwell times on angry female faces and minimally longer dwell times on angry male faces, social competence did not account for the relationship between anxiety symptoms and differential dwell time to angry vs. neutral female faces. To build on these findings, future research should include more diverse samples of sex, age, and ethnicity to provide a more comprehensive understanding of attentional processes and their implications for anxiety and social competence across different populations. Finally, insights from our findings might help develop targeted interventions to improve social functioning and reduce anxiety symptoms.

Data availability

The data that has been used is confidential. However, are available from the corresponding author on reasonable request.

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Author contributions

Sandra Meier: Conceptualization, Funding acquisition, Methodology, Supervision, Writing – original draft, Writing – review & editing. Hailey Burns: Conceptualization, Data curation, Investigation, Methodology. Bilikis Banire: Data curation, Investigation, Methodology, Writing – original draft, Writing – review & editing. Youna McGowan: Formal analysis, Writing – review & editing. Dawson Sutherland: Investigation, Formal analysis, Visualization. Sherry H. Stewart: Conceptualization, Methodology, Writing – review & editing. Ray M. Klein: Conceptualization, Methodology, Writing – review & editing.

Competing interests

The authors declare no competing interests.

Additional information

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