Aberrant Gaze Patterns in Social Anxiety Disorder: An Eye Movement Assessment during Public Speaking

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Abstract

Social anxiety disorder is maintained by biased attentional processing, which may encompass biases in the component engagement, disengagement, and avoidance attentional processes. However, few studies have directly examined whether such biases occur during social-evaluative conditions characteristically feared in social anxiety. The current study presents a novel approach for the assessment of attentional bias. Clinically socially anxious ($n = 27$) and control ($n = 29$) participants were required to give a speech in front of a pre-recorded audience displaying emotional social gestures while eye movement was recorded. Socially anxious individuals avoided attending to positive and threatening stimuli. At the onset of an emotional gesture, control participants were additionally faster to orient towards positive, relative to threatening gestures, while this bias was absent in socially anxious participants. The findings suggest that during conditions of social-evaluative stress, social anxiety is characterized by the attentional avoidance of emotional stimuli, and the absence of an engagement bias favouring positive stimuli.

Keywords: Social anxiety; eye gaze; attentional bias; avoidance; speech task; engagement; stress
**Introduction**

Social anxiety disorder (SAD) is a debilitating mental illness characterized by an excessive fear of negative social evaluation. Cognitive theories have emphasized the role of biased information processing in the maintenance and exacerbation of this condition, with particular regard for biased attentional processing (Clark & Wells, 1995; Mogg & Bradley, 1998; Rapee & Heimberg, 1997; Schultz & Heimberg, 2008; Williams, Watts, MacLeod, & Mathews, 1997). A strong base of research suggests that social anxiety is associated with an attentional bias toward the processing of threatening information (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007). Evidence further suggests that such biased attention may causally impact social anxiety (Amir et al., 2009; Schmidt, Richey, Buckner, & Timpano, 2009).

Studies examining anxiety-linked attentional bias have typically employed reaction time based assessments, such as the dot probe task (MacLeod, Mathews, & Tata, 1986). In this task, threat and neutral stimulus pairs are briefly presented, and then replaced by target probe appearing in the location vacated by one of the two stimuli. Socially anxious individuals have consistently exhibited speeded responses to the probe in the threat, compared to neutral, location, which is suggestive of an attentional bias to threat (Asmundson & Stein, 1994; Musa, Lépine, Clark, Mansell, & Ehlers, 2003).

However, such reaction time based tasks have been criticised for only providing a snapshot of attention (Bradley, Mogg, & Millar, 2000). For instance, when a stimulus is presented for a typical duration of 500ms, it is theoretically possible for multiple shifts of attention to occur within this time (Rayner, 1998). However, such shifts are not easily represented by reaction time. Similarly, tasks such as the dot probe are not well suited to the assessment of bias in these more dynamic aspects of attention. Selective attention comprises of both the initial engagement with a stimulus, and the subsequent disengagement from the
stimulus (Posner & Petersen, 1990). It is therefore possible that an attentional bias to threat may reflect either a facilitation of attentional engagement with threat stimuli, or a disruption to the disengagement from threat (Clarke, MacLeod, & Guastella, 2013).

Recent research has incorporated eye tracking technology, as eye gaze may provide a relatively direct and continuous measure of selective attention (Duchowski, 2002). Studies that have employed gaze-based measure of selective attention typically present threat-neutral and positive-neutral pairs of stimuli to participants, while eye gaze is continuously recorded. Anxious individuals have been found to exhibit a greater propensity or reduced latency to initially orient gaze towards threat stimuli (Calvo & Avero, 2005; Garner, Mogg, & Bradley, 2006; Mogg, Millar, & Bradley, 2000), which is suggestive of facilitated engagement to threat. Clinically socially anxious individuals have also been found to saccade away from positive social stimuli faster than threat, suggesting an attentional disengagement bias (Chen, Clarke, MacLeod, & Guastella, 2012).

In addition, these gaze-based tasks typically present stimuli for a relatively longer duration (e.g. three seconds), which allows for the examination of how attention is maintained over time. Clinically SAD individuals have been found to exhibit reduced total fixation time to emotional (i.e. both threat and positive) social stimuli, relative to controls (Chen et al., 2012). Reductions in total fixation time to specifically threatening stimuli have also been observed in anxious non-clinical populations (Calvo & Avero, 2005; Rohner, 2002). The findings suggest that SAD individuals may avoid attending to emotional information across longer durations. Taken together, social anxiety is associated with an attentional bias to threat, which may encompass biases in the engagement and disengagement components, and the use of avoidant attentional strategies (Cisler & Koster, 2010).

Previous literature has noted the advantage of eye tracking as a relatively direct measure of attention (e.g. Mogg et al., 2000). A further advantage of eye tracking is its
capacity to record data unobtrusively while participants perform naturalistically in realistic settings with direct practical relevance to the topic of interest (Duchowski, 2002). The speech task has commonly been used in social anxiety research (e.g. Abbott & Rapee, 2004), as public speaking necessitates social performance and includes the possibility of negative social evaluation, which is directly relevant to the fear experienced in SAD (American Psychiatric Association, 2000). Using this task, socially anxious individuals have been found to give more negative appraisals of their speech performance (Rapee & Lim, 1992), and expect a high probability and cost of negative evaluation resulting from their speech (Rapee & Abbott, 2007). Such biased cognitions are typically assessed before or after the speech. However, relatively fewer studies have assessed biased attentional processing online during the task. We have recently developed a novel methodology of recording gaze during a speech task, within our psychopharmacological (Alvares, Chen, Balleine, Hickie, & Guastella, 2012) and speech disorder research (Lowe et al., 2012). Broadly referred to as the Sydney Eye Movement and Speech Assessment (SEMSA), participants give an impromptu speech in front of a pre-recorded video of audience confederates who either displayed socially positive or threatening gestures, or remained neutral, while eye gaze is recorded. Relative differences in fixation time to these positive, threat and neutral stimuli provided assessment of biased selective attention. This task has yet to be applied to SAD. However, such an application would allow for the assessment of whether the attentional biases associated with SAD are evident under conditions with direct practical relevance to the disorder.

Hence, the present study sought to extend previous research by examining whether the attentional biases associated with SAD indeed occur during conditions of social-evaluative stress. Given previous findings, it was predicted that clinically socially anxious individuals, in comparison to controls, would avoid maintaining attention over time to either emotional social stimuli (Chen et al., 2012) or specifically threat (e.g. Calvo & Avero, 2005),
inferred from reduced total fixation time throughout the speech. It was further sought to extend previous work (Alvares et al., 2012; Lowe et al., 2012) by incorporating assessments of attentional engagement and disengagement. It was predicted that SAD would be associated with an increased propensity or speed to orient gaze towards threat stimuli, suggesting a bias in attentional engagement, and an increased latency to saccade away from threat, indicating a disengagement bias.

Method

Participants

Thirty-three clients (9 female) with a diagnosis of SAD were initially recruited from the Brain & Mind Research Institute, as part of a cognitive behavioural group therapy program. All clients met DSM-IV-TR (American Psychiatric Association, 2000) diagnostic criteria for SAD using the Anxiety Disorder Interview Schedule for Adults (ADIS-IV; Brown, Di Nardo, & Barlow, 1994). Exclusion criteria included a primary diagnosis of a psychotic disorder, current suicidal ideation, or a comorbid Axis II disorder. Clients were not excluded if they also met criteria for one or more comorbid Axis I disorders (n = 20), as is typical of community-based clinical samples (Clarke, Chen, & Guastella, 2012; Clarke, Hickie, Scott, & Guastella, 2012; Kroenke, Spitzer, Williams, Monahan, & Löwe, 2007). 40.74% additionally met criteria for another anxiety disorder. 33.33% were comorbid with a mood disorder, and 7.41% with a substance dependence disorder. Control participants were recruited from the University of Western Australia and the University of Sydney. As it was desirable to not include control participants with heightened anxiety vulnerability, controls were considered for inclusion if their score on the State Trait Anxiety Inventory Trait Version (STAI-T; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) was below the upper tercile
(i.e. less than 46, determined by a prior screening of 546 undergraduates), and their difference score on the abbreviated Social Phobia and Anxiety Inventory (SPAI-23; Roberson-Nay, Strong, Nay, Beidel, & Turner, 2007) was below the clinical cut-off score of 30 (Roberson-Nay et al., 2007). Twenty-nine controls (18 female) participated in this study, and were reimbursed either course credit or $15. All participants had correct or corrected-to-normal vision, and provided written consent. Six clinical participants were excluded from analysis due to eye tracker calibration problems. The remaining 27 SAD (7 female) and 29 control (18 female) participants were included for statistical analyses. The SAD group ($M = 27.33, SD = 10.17$) were significantly older than the control group ($M = 19.34, SD = 2.38$), $F(1,54) = 16.91, p < .001$, and had a lower relative proportion of females, $\chi^2(1, N = 56) = 7.39, p = .007$.

**Materials**

**Questionnaire measures.** Participants completed the SPAI-23 to assess SAD symptoms. The SPAI-23 is an abbreviated form of the Social Phobia and Anxiety Inventory (SPAI; Turner, Beidel, Dancu, & Stanley, 1989) and exhibits sound psychometric properties (Roberson-Nay et al., 2007). The SPAI-23 provides a social phobia subscale and an agoraphobia subscale. To specifically assess social anxiety excluding agoraphobia, a difference score of the two subscales is calculated. Participants were additionally administered the STAI-T to index general anxiety vulnerability, and the Depression Anxiety Stress Scale (DASS-21; Lovibond & Lovibond, 1995) to provide a further assessment of depression, anxiety and stress. Participants were additionally required to rate their state anxiety on a 100-point Subjective Units of Distress Scale (SUDS) immediately before and after their speech.
**Emotional social stimuli.** The emotional social stimulus set consisted of eight pre-recorded confederates. Four confederates were filmed with only a neutral expression. The remaining four confederates were filmed expressing three socially positive and three socially threatening gestures each, as well as maintaining a neutral pose. Positive gestures included a smile, smile and nod, and a serious nod indicating agreement. These gestures were respectively paired with the threatening gestures of a disgust expression, a disagreeing shake of the head, and a sigh of boredom. All emotional gestures were digitally edited to be six seconds in duration.

All 24 gestures (3 positive and 3 threatening gestures, each expressed by the 4 emotional confederates) were judged by nine independent raters on valence (positive, threat or neutral possibilities), and the degree of expressiveness of each gesture on a 5-point Likert scale. An inter-rater reliability analysis was conducted on gesture valence using the Fleiss Kappa statistic. The calculation yielded the maximum $\kappa = 1.0$, suggesting very high inter-rater reliability for gesture valence. A Wilcoxon Signed-Rank Test was conducted on expressiveness ratings for positive and threatening gestures. No difference in expressiveness for positive and threatening gestures was observed ($Z = -0.368, p = 0.713$).

**Experimental task display.** The audience display was presented on a large 152cm 16:9 plasma television, and consisted of the eight individually filmed confederates presented along the perimeter cells of a three by three array, as illustrated in Figure 1. The eight array cells were presented in front of a black background. Each cell contained one centred confederate face presented in colour, surrounded by a light grey backdrop. Each cell measured 32.3cm by 24.2cm. Each confederate occupied approximately 35% of their respective cell. The centres of adjacent faces were separated horizontally by 33.9cm and vertically by 25.4cm, subtending at 7.8° and 5.8° visual angle (VA) respectively, at a viewing
distance of 250cm. Two confederates intermittently displayed socially positive cues, two confederates displayed socially threatening cues, and other four confederates remained neutral throughout. All valence conditions were balanced for gender of the confederate. Additionally, two counter-balanced versions of the audience display were created, in which the emotionally expressive confederates conveyed the opposite valence between versions.

The audience display remained on the screen throughout the entire duration of the speech, but was nonetheless temporally divided into a number of trials. Each trial concerned an audience confederate “triplet” - one positive, one neutral and one threatening; who formed either a vertical or horizontal edge of the array. Hence, there were four possible confederate triplet positions - horizontal top, horizontal bottom, vertical left and vertical right. As the emotional audience confederates occupied the corner positions of the array, and the neutral confederates occupied the middle edge positions, each triplet thus consisted of a neutral confederate flanked by one positive and one threatening confederate.

To permit the assessment of how readily participants directed their gaze towards (i.e. engaged with) and away from (i.e. disengaged from) socially positive and threatening stimuli, it was necessary to cue participants' gaze either upon or adjacent to emotionally expressive confederates. For each trial, a directional cue was initially presented for 1s on the face of one of the members of a confederate triplet. The directional cue was a white flashing cross, 8cm wide, subtending at 1.8° VA. Immediately following the offset of the directional cue, the positive and threatening members of the confederate triplet simultaneously initiated an emotional gesture which lasted for 6s before returning to neutral expression.

Trials were designed to either assess engagement with, or disengagement from positive and threat stimuli. Each trial commenced with the presentation of the directional cue. For trials assessing attentional engagement, shown in Figure 2a, the cue served to align gaze with the face of the neutral triplet member, immediately prior to the initiation of positive and
threat gestures of the adjacent confederates. This then permitted assessment of the direction and latency to orient gaze towards an adjacent confederate following the onset of their positive or threatening gesture. For trials assessing disengagement, shown in Figure 2b, the directional cue served to align gaze with the location of the positive or threatening gesture immediately prior to its initiation. This then allowed the assessment of the latency to subsequently saccade away from the gesture. Given that the valid assessment of attentional engagement and disengagement necessitated that the directional cue did indeed secure initial attention, we only included trials in which this was evident (see Data Preparation for further details).

Taken together, there were 8 engagement, 4 disengagement from positive, and 4 disengagement from threat trials, randomized across the 4 confederate triplet positions, to create the 16 trials for each of the 2 counter-balanced versions of the audience display. Trials were presented at a rate of 1 every 10s, consisting of a 1s directional cue presentation, 6s emotional gesture presentation, and a 3s inter-trial interval in which all confederates displayed a neutral expression, thus resulting in a 2min 40s duration per audience display version.

**Tobii eye tracker.** During the speech, participants’ eye movements at the display were recorded with a Tobii X120 eye tracker. The X120 measured binocular gaze using pupil centre corneal reflection. Data was recorded at a rate of 120Hz and 5 points of calibration were used. The X120 automatically accommodates for head movements within a 30cm by 22cm by 30cm (width x height x depth) space, for movements up to 35cms$^{-1}$ in speed (Tobii Technology, 2008). This therefore readily accommodated the head movements made by the participants throughout the speech.
**Procedure**

Participants were informed that they would be participating in a study examining how people process social information. Participants then completed the self-report trait measures. Participants were then instructed that they would be required to give a six minute speech on the topic of their own choice in front of a pre-recorded audience. Participants were given free choice of topic, although a number of topic suggestions were provided, such as describing what they do for work or study, a hobby, or travelling. To induce a further sense of social evaluation, participants were informed that their speech would be filmed and subsequently evaluated by another individual. Participants then completed the SUDS, and were given five minutes preparation time. For the speech, participants stood approximately 250cm from the display. A lectern holding the eye tracker was situated in front of the participant, but did not obscure their vision of the display. The eye tracker was then positioned approximately 70cm at 25° below the participant’s eyes and then calibrated. Participants were instructed to treat the display as their audience, and additionally instructed to look momentarily at the directional cue whenever it appeared. The video camera was then switched on, and participants were instructed to commence their speech upon the onset of the audience video. During the speech, participants were initially presented with a 40s period in which all audience confederates displayed a neutral expression. The two counter-balanced audience displays were then presented sequentially using a crossover design – the order of presentation was counter-balanced across participants. If during the speech, participants were silent for 10s, they were given the standard prompt “Do you have anything more to say about the current topic?” If this was followed by another 10s of silence, the prompt “Perhaps talk about another interest you have?” was given. Following the speech, participants completed the SUDS again, and were then debriefed, reimbursed and thanked for their time.
Data Preparation

Raw eye movement data was initially cleaned using a two sample noise reduction filter (Stampe, 1993) and the interpolation of data for sample gaps less than 100ms. Fixations were subsequently defined as samples held within 1° VA for a minimum duration of 100ms. To delineate the socially positive, threatening and neutral regions of the display, rectangular areas of interest (AOIs) were spatially defined over each confederates’ face. AOIs were equal in size, each measuring 18.2cm by 22.2cm (width x height), subtending at 4.2° and 5.1° VA respectively. An additional non-face AOI was defined as the remaining space on the display which did not contain any social stimuli.

Total fixation time. To assess for the presence of attentional avoidance of social stimuli during the speech, the total fixation time towards positive, threat, neutral and non-face regions of the display were summed for the entire 5min 20s of the speech containing emotional gestures. The initial 40s neutral period was not included as this preceded the first emotional gesture occurrence.

Attentional engagement. Eye movement data from trials in which the directional cue appeared on the neutral face were used to calculate measures of attentional engagement. Such trials were included for analysis if (a) the participant did indeed fixate at the directional cue immediately prior to the onset of the emotional gestures, (b) the participant fixated on at least one of the two emotionally expressive faces within the six second period of gesture expression, and (c) the first fixation on an emotionally expressive face occurred at least 100ms following gesture onset. From this, engagement propensity and engagement speed scores to positive and threat stimuli were calculated. Engagement propensity was defined as the percentage of trials where gaze was initially oriented towards the threatening stimulus, as opposed to the positive stimulus. Engagement speed to a stimulus was defined as the mean latency to fixate at the stimulus of initial gaze orientation.
Attentional disengagement. Eye movement data from trials where the directional cue appeared on an emotional face were used to calculate a measure of attentional disengagement. Such trials were included for analysis if (a) the participant was fixating at the cross cue immediately prior to the onset of the emotional gesture, (b) a saccade away from the emotionally expressive face was made within the six second period of gesture expression, and (c) the saccade away from the emotionally expressive face occurred at least 100ms after gesture onset. Data from these trials were used to calculate the disengagement speed from positive and threat stimuli. Disengagement speed was defined as the mean latency to saccade away from the emotional face following gesture onset.

A series of mixed-design analyses of variance (ANOVAs) were conducted to examine for social anxiety-linked differences in the gaze-based measures of selective attention. Significant effects were further clarified using Bonferroni corrected pairwise comparisons as required. An alpha value of .05 was used for all statistical analyses. Adjusted p-values have been reported for the Bonferroni corrected pairwise comparisons.

Results

Questionnaire Measures

A series of one-way ANOVAs were conduct to assess group differences on questionnaire measures. As shown in Table 1, SAD participants, relative to controls, reported significantly higher social anxiety, and trait anxiety and depression, smallest $F(1,54) = 37.06$, $p < .001$. SAD participants further reported greater subjective distress immediately before, $F(1,54) = 29.22$, $p < .001$, and after, $F(1,54) = 20.41$, $p < .001$, the speech.

Attentional Avoidance
Total fixation time scores to positive, threat, neutral and non-face regions of the display were calculated to assess the prediction that socially anxious individuals avoid maintaining attention to social stimuli. Descriptive statistics are provided in Table 2. Due to significant violations of normality based on the Kolmogorov-Smirnov and Shapiro-Wilk tests, a square root transformation was applied to total fixation time scores. A mixed-design ANOVA was conducted on total fixation time scores, considering group (SAD vs. control) as the between-subjects factor and region (positive vs. threat vs. neutral vs. non-face) as the within-subjects variable. Mauchly’s test indicated a violation of the assumption of sphericity, $\chi^2(5) = 95.23, p < .001$, hence Greenhouse-Geisser adjusted values have been reported ($\epsilon = .63$). No group main effect was observed, $F(1,54) = 2.84, p = .098$, partial $\eta^2 = .05$. A main effect of region was evident, $F(1.88,101.76) = 32.22, p < .001$, partial $\eta^2 = .37$. Pairwise comparisons using Bonferroni adjustments showed that participants had greater fixation time towards neutral regions compared to all other regions of the display, smallest $M_{\text{diff}} = 2.42$, $SE_{\text{diff}} = .27, p < .001$. Importantly, a significant group by region interaction was found, $F(1.88,101.76) = 4.53, p = .015$, partial $\eta^2 = .08$, indicating that group differences in total fixation time varied across levels of region, illustrated in Figure 3. Pairwise comparisons using Bonferroni adjustments confirmed that SAD participants exhibited less total fixation time at positive, $M_{\text{diff}} = -1.23, SE_{\text{diff}} = .43, p = .006$, and threat regions, $M_{\text{diff}} = -1.09, SE_{\text{diff}} = .43, p = .015$, compared to controls, while no group differences occurred for neutral, $M_{\text{diff}} = .78, SE_{\text{diff}} = .61, p = .206$, or non-face regions, $M_{\text{diff}} = .85, SE_{\text{diff}} = .56, p = .134$.

Given that the audience display contained twice as many neutral regions, compared to threat or positive regions, this analysis was repeated with the neutral region total fixation time score halved. The main effect of valence was no longer evident, $F(1.63,87.93) = .44, p = .606$, partial $\eta^2 = .01$, suggesting that participants did not differentially attend to the audience display regions, when controlling for the size of the neutral region. Importantly, the
previously described group by region interaction was preserved, \( F(1.63,87.93) = 5.29, p = .011 \), partial \( \eta^2 = .09 \).

**Attentional Engagement and Disengagement Analysis**

For an attentional engagement or disengagement trial, it was necessary that the participant fixated at the directional cue immediately prior to the onset of the emotional gestures, in order to secure the initial locus of attention. Some participants did not appropriately fixate at the directional cue in a consistent manner and therefore did not have sufficient valid instances of engagement and disengagement recorded. Participants were included in the following analyses if at least two incidences of engagement with positive, engagement with threat, disengagement from positive and disengagement from threat were recorded. Attentional engagement and disengagement analyses were conducted on the 12 SAD and 20 control participants who satisfied this criteria. Descriptive statistics for the engagement and disengagement measures are provided in Table 2.

For the participants included in the engagement-disengagement statistical analyses, the average percentage of attentional engagement trials where there was a fixation on the directional cue was 55.21% (\( SD = 12.73 \)) for SAD participants, and 62.81% (\( SD = 16.41 \)) for controls. The average percentage of attentional disengagement trials where there was a fixation on the directional cue was 63.02% (\( SD = 12.63 \)) for SAD participants, and 72.81% (\( SD = 20.00 \)) for controls. Groups did not significantly differ on these percentages of engagement and disengagement trials, largest \( F(1.30) = 2.31, p = .139 \).

To address the possibility that the participants included in the engagement-disengagement analysis may have differed from the excluded participants, a multivariate analysis of variance (MANOVA) was conducted considering group (SAD vs. control) and inclusion (included vs. excluded) factors on participant questionnaire measures: the SPAI-23,
DASS-21, STAI-T and SUDS. A main effect of group was evident, $F(8,45) = 29.90, p < .001$, indicating that, as previously described, SAD participants reported higher social anxiety, trait and state anxiety, and depression. Importantly however, no main effect of inclusion was found, $F(8,45) = 1.31, p = .265$, and no group by inclusion interaction was present, $F(8,45) = .81, p = .597$, suggesting that participants included in the engagement-disengagement analysis did not differ from excluded participants on the trait and state measures of emotion.

**Engagement Propensity**

A one-way ANOVA was run comparing group (SAD vs. control) differences in engagement propensity scores. No group differences were evident for the average percentage of trials where participants engaged with threat or positive stimuli, $F(1,30) = 0.33, p = .573$.

**Engagement Speed**

Due to significant violations of normality based on the Kolmogorov-Smirnov and Shapiro-Wilk tests, a square root transformation was applied to engagement speed scores. To assess for anxiety-linked bias in engagement speed, a mixed-design ANOVA was conducted with group (SAD vs. control) as the between-subjects factor and valence (positive vs. threat) as the within-subjects variable. No group main effect was evident, $F(1,30) = .65, p = .426$, partial $\eta^2 = .02$, nor was a valence main effect observed, $F(1,30) = 2.44, p = .129$, partial $\eta^2 = .08$. Interestingly, a significant valence by group interaction was found, $F(1,30) = 8.67, p = .006$, partial $\eta^2 = .22$. Pairwise comparisons with Bonferroni adjustments confirmed that while controls were faster to engage with positive compared to threat stimuli, $M_{\text{diff}} = 6.70$, $SE_{\text{diff}} = 1.82, p < .001$, SAD participants showed no preference, $M_{\text{diff}} = -2.05$, $SE_{\text{diff}} = 2.35, p = .389$. Figure 4 illustrates this interaction.
**Disengagement Speed**

Due to significant violations of normality based on the Kolmogorov-Smirnov and Shapiro-Wilk tests, a square root transformation was applied to disengagement speed scores. To examine group differences in disengagement speed, a mixed-design ANOVA was run, considering the between-subjects factor group (SAD vs. control) and the within-subjects variable valence (positive vs. threat). No significant effects were observed between SAD and control participants, largest $F(1,30) = 2.68$, $p = .112$, partial $\eta^2 = .08$.

To ensure that the disengagement speed assessment was not confounded by potential group differences in the propensity to initiate disengagement from emotional stimuli, disengagement propensity scores were calculated and analysed. This score was defined as the percentage of trials where, within the six seconds of gesture presentation, a saccade was made away from the stimulus, following fixation at the stimulus, thus disengaging attention. For all participants, the disengagement propensity was 100%. Hence, no group differences were evident.

**Potential Influence of Age, Gender and Depression**

To address the potential extraneous influence of group differences in age, gender and depression (DASS21-D), partial correlations were calculated between these variables, and all total fixation time scores and engagement and disengagement scores, while controlling for social anxiety group influences. Bonferroni corrections were applied and adjusted $p$-values have been reported. Age, gender and depression were not found to significantly influence total fixation time to positive, threat, neutral or non-face regions, largest $r = -.24$, $p = .304$. Similarly, age, gender and depression were not found to influence engagement propensity, engagement speed or disengagement speed scores for positive and threat stimuli, largest $r =$ -
.23, $p = 1.000$. The data suggest that the observed social anxiety-linked differences for total fixation time and engagement speed were not likely due to group differences in age, gender or depression.

**Discussion**

The present study was designed to illuminate the mechanisms of attentional bias associated with SAD, by recording eye movements during a realistic public speaking simulation, in which pre-recorded audience confederates displayed socially positive and threatening gestures. This novel experimental design allowed a continuous quantitative measure of visual attention to be recorded online under conditions of social-evaluative stress. It was predicted that socially anxious participants would be associated with attentional avoidance throughout the speech. Consistent with this, these individuals exhibited reduced total fixation times to the positive and threatening audience confederates, in comparison to controls. The findings are consistent with previous research suggesting that social anxiety is characterized by the attentional avoidance of emotional social stimuli (Chen et al., 2012; Garner et al., 2006).

It was additionally predicted that SAD would be associated with biases in attentional engagement and disengagement. SAD was found to be associated with a bias in attentional engagement. While control participants were faster to orient gaze towards socially positive compared to threatening gestures, this positivity preference was absent for socially anxious individuals. The findings are consistent with the notion that while comparatively low anxious individuals may preferentially process positive information (Wadlinger & Isaacowitz, 2011), socially anxious individuals may neglect attending to positive stimuli (Pishyar, Harris, & Menzies, 2004). The findings add to the emerging base of research suggesting that, in addition to the preferential processing of threat, social anxiety may be maintained by the
deficient attentional processing of positive social stimuli (Kashdan, Weeks, & Savostyanova, 2011).

While social anxiety was found to modulate the engagement component of selective attention, it is noted that socially anxious individuals were not found to exhibit preferential engagement, in either the speed or propensity of orienting gaze, with threat stimuli per se, when compared to positive stimuli. This was inconsistent with the predictions of the present study, and also contrasts with previous research which observed preferential engagement with threat stimuli in anxious individuals (e.g. Mogg et al., 2000).

SAD was also not found to influence attentional disengagement, which is inconsistent with previous findings which have reported an anxiety-linked bias in disengagement (Chen et al., 2012; Fox, Russo, Bowles, & Dutton, 2001; Fox, Russo, & Dutton, 2002; Koster, Crombez, Verschuere, Van Damme, & Wiersema, 2006). The findings of the present study suggest that under conditions of social-evaluative stress, social anxiety may not influence the attentional disengagement from emotional stimuli.

It is possible that methodological differences may account for the absence of a social anxiety-linked bias in attentional disengagement. For instance, previous manual response tasks have assessed disengagement by presenting an emotional stimulus, followed by a probe which appeared on the opposite side of the display (e.g. Fox et al., 2001). Participants were therefore required to disengage their attention from the stimulus in order to respond to the probe. However, for the present study, no such requirement of attentional disengagement was needed. It is possible that biased disengagement may be more likely to be observed from tasks where there is a specific requirement to disengage attention (Armstrong & Olatunji, 2012).

Taken together, the biases in attentional selectivity observed in the present study may exacerbate social anxiety. Upon entering a social-evaluative situation, socially anxious
individuals may avoid attending to key emotional stimuli in their surrounding social environment. While this may arguably be employed as a safety-seeking strategy (Cisler & Koster, 2010), as such avoidance does not allow for accurate reappraisals of the social situation (Clark & Wells, 1995; Hofmann, 2007; Rapee & Heimberg, 1997), or the attenuation of anxiety via habituation of the feared social stimuli (Amir, Foa, & Coles, 1998; Mogg, Bradley, DeBono, & Painter, 1997). Emerging evidence further suggests that attending to positive information may be protective during conditions of stress (Wadlinger & Isaacowitz, 2008), and may mediate the relationship between social anxiety and anxious reactivity in response to a speech task (Taylor, Bomyea, & Amir, 2010). Hence, if socially anxious individuals do not readily engage attention with positive information, they may miss out on the protective mechanisms associated with such processing, thus maintaining their social anxiety.

The present study employed a novel variant of a speech task, whereby eye movements were recorded to provide an online assessment of attentional bias. Public speaking is a typically feared task in SAD (American Psychiatric Association, 2000) as it requires social performance which may potentially result in negative social evaluation. Hence, the present study extends previous research by demonstrating that the biased attentional processing associated with SAD indeed occurs during a social task with direct practical relevance to the disorder. However, it is acknowledged that while the present study focused on a performance-based social task, certain individuals with SAD may alternatively find interaction-based social tasks particularly difficult (American Psychiatric Association, 2000). Future research may seek to further examine selective attention during a social interaction context.

While the present study found SAD-linked differences in attentional processing, it is to be noted that groups were not matched on age, gender, or other trait measures such as
depression. While the analyses conducted suggest that these factors did not modulate the key SAD-linked findings, such potentially extraneous influences cannot be fully ruled out. It is also noted that several participants did not attend to the cue on sufficient occasions and were therefore unable to be included in the engagement and disengagement analysis. Of the participants included for the engagement and disengagement analysis (12 out of 27 SAD participants; 20 out of 29 controls), the consistency with which they fixated at the directional cue was also less than ideal ($M = 63.46\%$). While the trait and state measures of anxiety and depression were not found to influence the fixation at the directional cue, we speculate that factors not examined in the present study may have contributed to this. For instance, participants may have had difficulty with regard to the task switching between responding to the cue and performing the speech.

While the limitations of the engagement-disengagement assessment are acknowledged, the present study essentially sought to assess selective attention during a task with direct relevance to SAD. This intended focus on ecological validity inherently resulted in some design trade-offs, precluding for instance, the possibility of presenting a larger number of trials. Future research designs may benefit from manipulating the audience display in a manner such that following the presentation of the directional cue, the subsequent onset of the emotional gesture pair does not occur until a fixation is detected on the directional cue. This gaze-contingent design may increase the number of trials which may be considered for engagement and disengagement assessment.

Future research may seek to examine the clinical utility of this task. The attentional engagement bias and avoidance findings of the present study provide the basis for two targeted interventions for SAD, and objective markers to assess clinically relevant change. With regard to the former, attentional bias modification (ABM; MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002) has been identified as a potential intervention for
SAD. A typical ABM task consists of the presentation of a number of probe response trials which encourage the deployment of attention away from threat (MacLeod et al., 2002) or towards positive stimuli (Grafton, Ang, & Macleod, 2012). ABM administration has been found to attenuate anxious reactivity in response to a subsequent stressor (MacLeod et al., 2002) and repeated administration has been associated with the reduction of social anxiety symptoms in SAD (Amir et al., 2009; Schmidt et al., 2009). It is possible that the attentional engagement assessment developed by the present study may provide a marker for the bias modification properties of ABM, while the social-evaluative conditions employed by the present study may concurrently allow for the examination of attenuated anxiety reactivity following ABM administration. Moreover, attentional avoidance is a common safety-seeking strategy which maintains social anxiety (Cisler & Koster, 2010; Hofmann, 2007), and interventions such as exposure therapy have sought to address this (Clark, 1999; Clark & Wells, 1995). The total fixation time assessment implemented in the present study may potentially be used to directly assess the subsequent attenuation of avoidance strategies following treatment during a social-evaluative condition with direct practical relevance to SAD.

The findings of the present study suggest that during a social-evaluative situation socially anxious individuals avoid sustaining their attention towards emotional social stimuli, and are additionally impaired in engaging attention towards positive social stimuli. The current study presents a novel methodology for the assessment of the aberrant attentional processes which characterize social anxiety psychopathology.

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References


Tables

Table 1. Means, standard deviations and F-scores for questionnaires completed by social anxiety disorder (SAD) and control participants: the abbreviated Social Phobia and Anxiety Inventory (SPAI-23), the State Trait Anxiety Inventory Trait Version (STAI-T), the Depression Anxiety Stress Scale (DASS-21), and the Subjective Units of Distress Scale (SUDS).

<table>
<thead>
<tr>
<th>Questionnaire</th>
<th>SAD</th>
<th>Control</th>
<th>F(1,54)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>SPAI-23 Social Phobia</td>
<td>49.61</td>
<td>10.11</td>
<td>15.96</td>
</tr>
<tr>
<td>SPAI-23 Agoraphobia</td>
<td>9.31</td>
<td>6.67</td>
<td>1.38</td>
</tr>
<tr>
<td>SPAI-23 Difference</td>
<td>40.30</td>
<td>9.49</td>
<td>14.58</td>
</tr>
<tr>
<td>STAI-T</td>
<td>59.80</td>
<td>8.68</td>
<td>30.90</td>
</tr>
<tr>
<td>DASS-21 Depression</td>
<td>22.30</td>
<td>10.21</td>
<td>3.45</td>
</tr>
<tr>
<td>DASS-21 Anxiety</td>
<td>20.44</td>
<td>9.04</td>
<td>2.41</td>
</tr>
<tr>
<td>DASS-21 Stress</td>
<td>24.44</td>
<td>9.32</td>
<td>7.31</td>
</tr>
<tr>
<td>SUDS Pre</td>
<td>66.91</td>
<td>20.71</td>
<td>35.52</td>
</tr>
<tr>
<td>SUDS Post</td>
<td>49.31</td>
<td>23.85</td>
<td>22.07</td>
</tr>
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</table>

*p < .001
Table 2. Means and standard deviations for the gaze-based measures of selective attention for social anxiety disorder (SAD) and control participants.

<table>
<thead>
<tr>
<th>Measure</th>
<th>SAD</th>
<th>Control</th>
</tr>
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<tbody>
<tr>
<td></td>
<td><em>M</em></td>
<td><em>SD</em></td>
</tr>
<tr>
<td><strong>Total Fixation Time (s)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>28.35</td>
<td>17.36</td>
</tr>
<tr>
<td>Threat</td>
<td>26.48</td>
<td>16.29</td>
</tr>
<tr>
<td>Neutral</td>
<td>65.57</td>
<td>37.36</td>
</tr>
<tr>
<td>Non-Face</td>
<td>40.50</td>
<td>29.53</td>
</tr>
<tr>
<td><strong>Engagement Propensity (%)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>55.95</td>
<td>12.14</td>
</tr>
<tr>
<td>Threat</td>
<td>44.05</td>
<td>12.14</td>
</tr>
<tr>
<td><strong>Engagement Speed (ms)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>1871.28</td>
<td>1157.29</td>
</tr>
<tr>
<td>Threat</td>
<td>1633.79</td>
<td>579.93</td>
</tr>
<tr>
<td><strong>Disengagement Speed (ms)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>832.10</td>
<td>459.24</td>
</tr>
<tr>
<td>Threat</td>
<td>951.97</td>
<td>510.81</td>
</tr>
</tbody>
</table>
Figure 1. The audience display layout presented during the speech task. Confederates who intermittently expressed socially positive (P) and threatening (T) gestures throughout the speech are located in the corner positions of the array.
Figure 2a. For trials assessing attentional engagement, gaze is initially directed to the location of the neutral face. Immediately following the offset of the directional cue, the adjacent emotionally expressive confederates simultaneously display a social gesture. Gaze is subsequently directed to one of the gestures. The direction and latency of this saccade is recorded to compute engagement propensity and engagement speed scores respectively.

Figure 2b. For trials assessing attentional disengagement, disengagement from threat in this example, gaze is initially directed to the location of the threatening gesture. Immediately following the directional cue offset, the two emotionally expressive confederates display a social gesture. The latency subsequently saccade away from the threatening gesture is recorded to calculate disengagement speed scores.
Figure 3. Total fixation times to the positive, threat, neutral and non-face display regions during the speech for social anxiety disorder (SAD) and control participants. Error bars represent the standard error.
Figure 4. Mean engagement speed scores for social anxiety disorder (SAD) and control participants. Error bars represent the standard error.