Attention to faces and gaze-following in social anxiety: preliminary evidence from a naturalistic eye-tracking investigation

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Abstract

Social attentional biases are a core component of social anxiety disorder, but research has not yet determined their direction due to methodological limitations. Here we present preliminary findings from a novel, dynamic eye-tracking paradigm allowing spatial-temporal measurement of attention and gaze-following, a mechanism previously unexplored in social anxiety. 105 participants took part, with those high (N = 27) and low (N = 25) in social anxiety traits (HSA and LSA respectively) entered into the analyses. Participants watched a video of an emotionally-neutral social scene, where two actors periodically shifted their gaze towards the periphery. HSA participants looked more at the actors' faces during the initial 2s than the LSA group but there were no group differences in proportion of first fixations to the face or latency to first fixate the face, although HSA individuals' first fixations to the face were shorter. No further differences in eye movements were found, nor in gaze-following behaviour, although these null effects could potentially result from the relatively small sample. Findings suggest attention is biased towards faces in HSA individuals during initial scene inspection, but that overt gaze-following may be impervious to individual differences in social anxiety. Future research should seek to replicate these effects.

Keywords: Attentional bias, Social phobia, Social attention, Threat detection, Gaze cueing

Social anxiety disorder (SAD) is a prevalent, debilitating anxiety disorder, characterized by an intense fear of scrutiny and negative social evaluation (American Psychiatric Association, 2013). Individuals with SAD typically avoid social or performance-based situations where possible, to reduce the fear of potential social rejection or humiliation (Bögels et al., 2010). It has been found that individuals experiencing social anxieties are unlikely to seek help for their symptoms (Weiller, Bisserbe, Boyer, Lepine, & Lecrubier, 1996). Coupled with the suggestion that SAD represents only the extreme end of the spectrum of social anxiety (SA) symptomology, it is likely that undiagnosed SAD may be common in the general population (Ruscio, 2010; Weiller et al., 1996).

Attentional biases appear to be a core component of SAD. Empirical research and cognitive models place emphases on atypical attentional processes in the disorder (Bögels & Mansell, 2004; Clark & Wells, 1995). In addition, recent therapeutic interventions for the condition have focused on modifying attentional processes to reduce anxiety, with some success (Davidson et al., 2004; Fistikci, Saatcioğlu, Keyvan, Kalkan, & Topçuoğlu, 2015). However, despite the established link between SAD and attention and an active research community in the field, it is surprising that a consensus as to the precise nature of these biases has yet to be reached.

In other research fields, the term “social attention” is often to describe the mechanisms by which social stimuli both attract and direct our attention, and these two mechanisms have often been examined together in both non-clinical participants and those with autism spectrum disorders (ASD) (Frischen, Bayliss, & Tipper, 2007; Nasiopolous, Risko, & Kingstone, 2015). Whilst in non-clinical participants, faces usually attract attention and fixations towards them (Birmingham, Bischof, & Kingstone, 2008; Smilek, Birmingham, Cameron, Bischof, & Kingstone, 2006), a shift of eye-gaze direction of a social partner often causes a corresponding shift in attention *away* from the face, in the direction of gaze, —so-called "gaze following." Gaze following is the first manifestation of theory of mind abilities in infants and as such is critical to successful social developmental (Carpenter, Nagell, & Tomasello, 1998; Morissette, Ricard, & Décarie, 1995). Although reporting equivocal findings, studies finding atypicalities in attention to social stimuli are certainly well-documented in SAD. Surprisingly however, the gaze following mechanism has never been studied in this group.

Attentional biases in social anxiety

Of the two main competing theoretical accounts of attentional biases towards social stimuli in SA, one suggests SA individuals are vigilant for threatening social stimuli such as angry faces, resulting in increased attention toward them (Rapee & Heimberg, 1997). The other asserts that people with SA avoid social stimuli (Chen, Ehlers, Clark, & Mansell, 2002; Heinrichs & Hofmann, 2001) which may serve as a *safety behaviour* by reducing potential for negative emotional experience . Eye contact in particular is avoided in SA (Horley, Williams, Gonsalvez, & Gordon, 2003, 2004). These discrepant findings have been explained in terms of a vigilance-avoidance model: An initial bias towards, followed by subsequent avoidance (Heinrichs & Hofmann, 2001; Mogg, Bradley, Miles, & Dixon, 2004; Mogg, Bradley, de Bono, & Painter, 1997). Other researchers suggest that SA individuals experience difficulty disengaging attention from threatening cues, resulting in increased attention towards stimuli over time, referred to as a *maintenance* of attention (Buckner, Maner, & Schmidt, 2010; Rapee & Heimberg, 1997).

The dot-probe task

The dot-probe task has been a widely used paradigm to study attentional bias in SAD (Bantin, Stevens, Gerlach, & Hermann, 2016). A common finding is that SA participants are quicker to correctly detect the probe when it replaces a face showing angry expressions, compared to neutral expressions supporting vigilance or *hypervigilance* for social threat (Klumpp & Amir, 2009; Mogg & Bradley, 2002; Mogg, Philippot, & Bradley, 2004). Other work has shown a failure to disengage attention from such stimuli, supporting a maintenance hypothesis (Amir, Elias, Klumpp, & Przeworski, 2003; Buckner et al., 2010). To add further confusion, other dot-probe studies have shown SA individuals avoid faces altogether in favour of non-social stimuli (Chen et al., 2002; Mansell, Clark, Ehlers, & Chen, 1999).

An important limitation of the task is that it provides only a snapshot of behavioural response to the stimulus at one time point (Klumpp & Amir, 2009). To counter this, some researchers have varied the duration of stimulus presentation (Mogg, Philippot, et al., 2004; Stevens, Rist, & Gerlach, 2009) but this still limits temporal analysis to discrete, pre-defined time bins created a priori. Even with such modifications, the dot-probe task has been found to be an unreliable measure of attentional bias in SA, and one which may be uncorrelated with SA symptomology (Waechter, Nelson, Wright, Hyatt, & Oakman, 2014). Eye-movement based paradigms have been employed in an attempt to overcome these limitations, as they are capable of measuring attention over both space and time.

Eye-movement based paradigms

A review of eye-tracking tasks in affective disorders (Armstrong & Olatunji, 2012) highlighted that *hypervigilance* is typically operationalised by examining the initial fixations directed towards stimuli (Armstrong, Olatunji, Sarawgi, & Simmons, 2010) *avoidance* by reduced early fixations to stimuli over longer periods (Garner, Mogg, & Bradley, 2006; Rinck & Becker, 2006) and *maintenance* by longer/more frequent fixations to stimuli after initial orienting (Buckner et al., 2010).

However, operationalised definitions do vary considerably across studies, leaving open different interpretations of results. As with the dot-probe task, one problem is the limited (around 2 seconds) temporal window that analyses are usually conducted within. As an example, the only study to examine attentional bias to (static) emotionally *neutral* social stimuli , Garner, Mogg and Bradley (2006), considered only the properties of the first fixation occurring within a 1500ms trial. The parameters of this fixation were taken to evaluate the vigilance, avoidance and maintenance hypotheses (indicated by first fixation location, latency and duration). Interestingly, the direction of the attentional bias seemed dependent on whether participants were in a high or low stress condition, with avoidance and vigilance resulting, respectively. However, it is unlikely that a solitary fixation could validly assess either maintenance or avoidance theories given both hinge on *changes* in attention *over time*. Other researchers have employed a more sensitive approach by analysing changes in individual fixations during scene inspection but again this is usually limited to a 2 second period (Amir et al., 2003; Buckner et al., 2010). Waechter et al (2014) were the only authors to examine a longer period of 5s separated into 500ms epochs. Interestingly, they found that HSA individuals looked more at angry faces but only between 1000-2000ms after stimulus presentation, which would better support a maintenance of attention, rather than a hypervigilance hypothesis.

In their review, Armstrong and Olatunji (2012) concluded that although many studies did support an initial hypervigilance for threat, in light of such equivocal findings supporting maintenance and avoidance theories, "further insight into the time course and components of attentional bias [in affective disorders] may require a broader set of tools for measuring attention [than currently utilised]" (p.705). Despite the rich data available to eye-tracking researchers, and six subsequent years of research, it seems that the potential for this method has still yet to be realised.

Whilst this may be the case in the affective disorders, studies of typical social attention have begun to employ more complex stimuli to increase ecological validity (Gobel, Kim, & Richardson, 2015; Gregory et al., 2015; Laidlaw, Foulsham, Kuhn, & Kingstone, 2011) as is true in the ASD literature (Auyeung et al., 2015; Freeth, Foulsham, & Kingstone, 2013). As a result, subtle group differences have emerged. For example Freeth et al. (2010) demonstrated delayed fixations to faces embedded within everyday scenes in ASD, an effect which was visible only in the early stages of viewing, whilst a recent review and meta-analysis found that sufficient social complexity of stimuli was critical to highlighting atypicalities in the ASD (Chita-Tegmark, 2016).

Within the SAD literature, the only eye-tracking study to use dynamic complex social stimuli surprisingly did not conduct temporal data analyses (Chen, Thomas, Clarke, Hickie, & Guastella, 2015). SAD participants looked less at the positive and negative faces of audience members whilst giving a four minute speech than controls, suggesting some avoidance, but no differences in gaze were found during an initial period where the audience maintained neutral expressions. However, given the lack of fine-grained temporal analyses, meaningful evaluation of the competing theoretical accounts is again difficult.

Despite a wealth of research into attentional bias in SA, it is still not known how attention is deployed dynamically during social scenarios. As such, the current study charted the eye movements of individuals with low and high levels of SA (LSA and HSA respectively) whilst they viewed an emotionally-neutral, social scene (Gregory et al., 2015). In order to assess the vigilance, avoidance and maintenance hypotheses we conducted both temporal and spatial analysis of eye-movements. Given the task has not previously been used with this group, we did not make any specific predictions based on the three prominent theories of attentional bias in SA. Rather, our aim was to assess how attention unfolded under free-viewing of an everyday social scene, and determine the basic eye movement characteristics of participants high in SA, an endeavour not previously attempted.

The current paradigm not only allows for measurement of attention towards social stimuli but also gaze-following, a mechanism which has not previously been explored in SA.

Gaze-following and social anxiety

Many studies have shown that direct gaze is avoided in SAD due to its potential as a threatening cue (Clark & Wells, 1995; Horley et al., 2004; Roelofs et al., 2010). Yet viewing someone's averted gaze, which has been repeatedly shown to cause an obligatory reorienting of attention in nonclinical individuals (Driver et al., 1999; Kuhn & Benson, 2007) has never been investigated in SA. Schmitz et al. (2012) found enhanced event related potentials (ERPs) in SA individuals when viewing averted eye-gaze but did not measure gaze-following per se. Given averted gaze indicates attention has been directed away from the observer, the authors suggested the effect may reflect a negative self-evaluation caused by apparent disinterest of the stimulus in the observer.

Individuals with high trait anxiety may be more prone to having their attention oriented by eye-gaze under certain conditions than those without (e.g. with fearful faces;

(Fox, Mathews, Calder, & Yiend, 2007)) but as above, previous tasks have lacked in ecological validly in several respects. First, rather than taking the behavioural response of an imitative gaze shift in the direction of the cue as a measure of gaze-following, the “gaze-cueing task”, a variant of the Posner cueing paradigm (Posner, 1980) takes “cueing” or “congruency” reaction time effects as the dependent measure (the difference in manual or saccadic response times to cued versus uncued targets). In fact, participants are rarely found to make imitative eye movements in such tasks, questioning whether such designs are measuring gaze-following at all (Gregory & Hodgson, 2012; Kuhn & Benson, 2007). Second, the task has been repeatedly shown to be insensitive to group membership in ASD studies (Kuhn et al., 2010; Kylliainen & Hietanen, 2004; Swettenham, Condie, Campbell, Milne, & Coleman, 2003) despite atypical gaze-following being frequent in naturalistic settings in ASD (Leekam, Hunnisett, & Moore, 1998). Third, the stimuli themselves lack natural complexity, at best showing photographs (Gregory & Hodgson, 2012) and at worst, schematic drawings (e.g. (Friesen & Kingstone, 1998)). It has been questioned whether the resulting cueing effects are reflecting social processes at all given other non-social directional cues produce similar results (Kuhn & Kingstone, 2009; Tipples, 2002). These concerns led some to develop more naturalistic tasks (Gallup, Chong, & Couzin, 2012; Gregory et al., 2015). Using the current paradigm with non-clinical participants, Gregory et al., (2015) showed that participants overtly followed gaze around 30% of the time, which, contrary to findings from the gaze-cueing literature , suggests that in natural contexts gaze-following is far from obligatory .

Given gaze-following has never been studied in SA, our hypothesis was two-tailed. If HSA individuals interpret the cue in a negative, self-referential manner (Schmitz et al., 2012) they may follow gaze more than LSA individuals. Alternatively, if those high in SA avoid gaze (Roelofs et al., 2010), they may fail to notice the shifts and therefore may follow gaze less.

Methods

Participants

Students and participant pool members from Bournemouth University volunteered to take part in exchange for £5 or course credit. All had normal or corrected to normal vision and declared themselves to be free of neurological disorder. 105 participants took part in the study (*M* age: 19.91 years, *SD*: 2.50) of (88 females). Data collection was conducted at Bournemouth University. Five participants were excluded due to poor calibration of the eye tracker. Post-experiment, the top quartile of participants, based on their score on the Leibowitz Social Anxiety scale (LSAS; (Liebowitz, 1987) (see below) were assigned to the high social anxiety group (HSA; N = 27; Mean LSAS score = 78.93 *SE*= 2.78, 25 females) and the bottom quartile to the low social anxiety group (LSA; N = 27; Mean LSAS score = 26.63, *SE* = 1.10, 23 females). The mean score of the HSA group on the LSAS was above the thresholds considered to indicate both SAD (30 or above) and its generalised sub-type (60 or above) which is the more severe of the two presentations (Mennin et al., 2002). Independent samples t-test showed LSAS scores were significantly different between groups, t (52) = 17.46, $p < .001$. The remaining participants' data were excluded from the subsequent analyses. The study was approved by the ethics committee of Bournemouth University (IDs 1883 and 4928).

Stimulus, Materials and Apparatus

Participants completed the LSAS as a measure of trait social anxiety. The LSAS is a 24-item instrument often used by clinicians to screen for SAD. Participants rate their fear or avoidance of social and performance situations on a scale of 0-3, with higher ratings indicating greater fear or avoidance. The LSAS has excellent psychometric properties, with Cronbach's alpha of .95 in SAD patients and .92 in nonclinical participants (Fresco et al., 2001). Test-retest reliability it also good at $r = .82$ (Baker, Heinrichs, Kim, & Hofmann, 2002).

The stimulus was that used by Gregory et al (2015). Briefly, it comprised of a two minute video depicting two females sitting in a waiting room, who shifted their gaze on five occasions towards anticipated events or objects in the periphery. The actors interacted with one another briefly on only two occasions. Otherwise, the actors remained seated, reading magazines or interacting with mobile phones, maintaining neutral facial expressions. The sound track was removed from the video.

Eye movements were recorded using the Eyelink 1000 desk-mounted eye tracker (SR Research, Canada). Participants sat 60cm from the display screen, a 22" ProNitron 21/750 CRT monitor, connected to a HP Compaq dc7800 display computer which was connected to a Dell Optiplex 760 host computer. Participants' faces were stabilised by a chin rest. Pupil and corneal reflection were recorded monocularly at a rate of 2000Hz.

Procedure

Participants gave written informed consent to participate and provided basic demographic information. They were then seated in front of the eye tracker, where a 9-point calibration procedure was conducted. Participants were informed that a video would be displayed on the screen and that they should watch this until it finished, without any specific viewing instructions. Immediately prior to the onset of the video, a drift correct procedure was carried out which identified any eye drift post-calibration. The video was then presented at 720 x 400 pixels resolution. Participants completed the LSAS and were verbally debriefed.

Results

Eye movement measures

We elected to examine a range of eye movement measures in this study to allow us to assess the presence of hypervigilance/vigilance, maintenance and/or avoidant viewing strategies within our sample. To examine hypervigilance, we analysed characteristics of the first fixation made by participants after the onset of the stimulus in line with previous research (Armstrong & Olatunji, 2012; Armstrong et al., 2010; Garner et al., 2006). Specifically, we assessed the ***proportion of first fixations made to the face*** of the actor. If this figure was significantly higher for the HSA group, this would support a hypervigilance explanation. Second, we also assessed the ***first fixation duration*** of those initial fixations made to the face. In the eye movement version of the dot-probe task, longer first fixation durations in HSA individuals have been suggested to demonstrate a maintenance of attention on the stimulus, whereas shorter fixation durations have been taken to indicate avoidance (Armstrong & Olatunji, 2012; Garner et al., 2006). A related measure of hypervigilance, but one which is rarely reported in eye movement studies of anxiety (Armstrong & Olatunji, 2012) was the ***latency to first fixate the face***. Again, a significantly shorter latency would indicate a hypervigilance whereas a longer latency may suggest avoidance.

As the current paradigm uses a dynamic stimulus, it permits the analysis of unfolding attention allocation over time. We therefore analysed the ***proportion of dwell time to the face*** over the early part of the scene to determine the presence of maintenance or avoidance of the face in the HSA group (Armstrong & Olatunji, 2012; Buckner et al., 2010; Rinck & Becker, 2006). Dwell time is a measure of eye movement samples falling within particular interest area over a defined period of time. The higher the proportion of dwell time, the higher the attentional priority of that area. The maximum period of initial scene viewing to be previously assessed in a HSA sample has been 5 s (Waechter et al., 2014), whereas 2 s has been a more commonly used time frame (Amir et al., 2003; Buckner et al., 2010). Therefore we divided the data into ten 500ms time bins from 0 to 5000ms and analysed dwell time to the face over the ***initial 2s period*** and the ***initial 5s period*** to allow us to map changes in attention over this critical time period and to allow comparison to the previous literature.

Finally to provide an overall assessment of the eye movements of participants over the entire scene, we analysed ***overall proportion of dwell time to each interest area*** (faces, bodies, background). Differences in dwell time particularly to the face between the groups over the whole scene might support a maintenance or avoidance interpretation (Chen et al., 2015).

We also analysed some basic eye movement characteristics of the participants over the whole trial. Differences between the groups might indicate more global differences in attentional style which are not necessarily dependent on the specific content of the scene.

In basic eye movement research, shorter fixation durations are reported with increased scene complexity or expertise (Holmqvist et al., 2011) and in social settings, shorter fixations are observed when viewing others in a live context compared with when viewed as a pre-recording (Gregory & Antolin, 2018) and are shorter in people with social anxiety (Horley et al., 2003). This suggests that as the social and/or cognitive demands of a situation increase, fixation durations reduce. We therefore might expect to find shorter fixation durations for the HSA group. In addition, those who are socially anxious have longer scanpaths than those who are not, and this has been interpreted as being a marker of a vigilant viewing strategy referred to as “hyperscanning”. (Chen et al., 2015; Holmqvist et al., 2011; Horley et al., 2003). A longer scanpath could be the result of larger amplitude saccades, more frequent saccades/fixations and/or shorter duration fixations or a combination thereof. Therefore in order to precisely isolate any differences between the groups, as well as analysing ***mean fixation duration*** and ***total scanpath length***, we additionally analysed ***total number of fixations*** and ***mean saccade amplitude*** between the groups across the whole trial

Data handling

The stimulus was divided into interest areas (IAs) and data was analysed using Dataviewer (SR Research, Canada). IAs were faces and bodies of the actors, as well as the targets of the gaze shifts (e.g. a door, a bookshelf) the latter being relevant only to the gaze following analyses, together with a rectangular IA which encompassed the whole video window . For the general viewing analyses, the background IA constituted this whole video area minus the social IAs (faces and bodies), but included the gaze target IAs described above (Gregory et al., 2015).

Outlier handling

For each variable calculated, we considered outlying data points to be those which we more than 1.5 times the interquartile range for that variable. Rather than removing participants’ data, we *Winsorized* (Tukey, 1962) individual outlying data points to maximise the data available for analysis. Winsorizing involves amended outlying data points to the nearest value which is not an outlier. This procedure was carried out on a total of 45 data points across all analyses, representing only 3.97 % of data points.

All post-hoc tests presented are Bonferroni corrected for multiple comparisons. Huynh-Feldt corrected values are reported for variables with three or more levels.

First fixations to face

To examine possible hypervigilance, an independent samples t-test was conducted on the proportion of first fixations which were directed to the face between the groups.

There was no difference between groups, t (52) = .945, p = .349, d = .257, despite a higher mean for the LSA group (M = .815, SE = .076) compared to the HSA group (M = .704, SE = .090)

Of the first fixations which landed on the face, the fixation durations of the HSA group were significantly shorter than those of the LSA group, t (28.68) = 2.221, p = .034, d = .677 (HSA: M = 353.63ms, SE = 40.82; LSA: M = 578.59ms, SE = 92.68). However there was no group difference in the mean latency to first fixate the face, t (52) = .905, , d = .003

Dwell time to face during initial 2 seconds

A 2 (Group: LSA, HSA) x 4 (Time: 0-500ms, 500-1000ms, 1000-1500ms, 1500-2000ms) mixed ANOVA was conducted on proportion of dwell time to the face over the first 2 seconds of the scene. A significant effect of Time emerged, F (2.77, 144.22) = 12.99, p < .001, η^2_p = .200 as well as a significant effect of Group, F (1, 52) = 5.48, p = .023, η^2_p = .095. The HSA group spent more dwell time on the face than the LSA group (LSA: M = .523, SE = .045; HSA: M = .672, SE = .045) The interaction between Group and Time was not significant, F (2.77, 144.22) = .39, p = .746, η^2_p = .007.

Dwell time to face during initial 5 seconds

We then conducted the same analysis but this time over the first 5 seconds using a 2 (Group) x 10 (Time: 0-500ms, 500-1000ms, 1000-1500ms, 1500-2000ms, 2000-2500ms, 2500-3000ms, 3000-3500ms, 3500-4000ms, 4000-4500ms, 4500-5000ms) mixed ANOVA.

There was still a main effect of Time, F (6.39, 332.73) = 4.811, $p < .001$, $\eta^2_p = .085$, but the effect of Group was no longer significant, F (1, 52) = 1.65, $p = .204$, $\eta^2_p = .031$. The interaction was non-significant, , F (6.39, 332.73) = .574, $p = .762$, $\eta^2_p = .011$.

The results demonstrate that any differences between groups in dwell time to the face were limited to the first 2 seconds. The time course of dwell time to the face in the two groups over the first five seconds of the scene can be seen in Figure 1.

[insert figure 1 here]

Figure 1: Proportion of dwell time directed to the face in the LSA and HSA groups over the first 5 seconds of the scene. Error bars represent standard error of the mean.

General viewing behaviour over the full trial period.

Although our particular period of interest was early in the scene we also wished to compare the groups in terms of their general viewing behaviour and eye movement characteristics.

However, we found no differences between the groups in terms of fixation number (t (52) = .201, $p = .841$, $d = .082$,), fixation duration (t (52) = .399, $p = .692$, $d = .108$), saccade amplitude (t (52) = .533, $p = .596$, $d = .154$) and scanpath length (t (52) = .520, $p = .570$ d = .145,) over the whole trial..

Finally to examine attention allocation different areas of the scene over the full trial period, over the whole scene, we conducted a further ANOVA on proportion of dwell time data from the full video period, which revealed a main effect of IA, F (1.807, 93.955) = 78.764, $p <$ .001 η^2_p = .602, with greater dwell time to heads, followed by bodies, followed by background (ps < .006). There was no effect of group, F (1, 52) = 1.254, p = .268, η^2_{p} = .024. and the interaction was not significant, F (1.807, 93.955) = 1.153, p = .316, η^2_{p} = .024.

Gaze-following.

Participants followed 28% of the gaze shifts, with a rate of 34.07% (*SE* = 5.53) in the LSA group compared to 29.63% (*SE* = 5.67) in the HSA group, however an independent t-test showed that this apparent difference was not significant, t (52) = .560, p = .578, d = .152.

As well as measuring overt saccadic responses to the gaze shifts of the actors, we also examined the amount of dwell time allocated to the gaze target before and after the gaze shift (see Gregory et al., 2015) as an average across all shifts. If participants spent more time looking at the target area after the shift (all of which were non-social in nature and should not be expected to attract a significant number of fixations), this would be taken to indicate that attention had been biased to that area. This would capture any gaze-elicited orienting that may not take the form of a direct saccade from the actor to the target and would therefore be missed in the first analysis.

A mixed 2 (Group: LSA, HSA) x 2 (period: pre-shift; post-shift) ANOVA showed a main effect of Period F (1, 52) = 46.40, p < .001, η^2_p = .472, with participants looking more to the IA after the gaze shifts than before them. However the effect of Group F (1, 52) = .034, p = .254, η^2_p = .001 and the interaction, F (1, 52) = .903, p = .346, η^2_p = .017 were not significant.

Taken together, the results suggest there were no differences in gaze following between the groups.

Discussion

This study set out to find evidence for the competing theories of attentional bias in social anxiety using a novel naturalistic eye-movement task where actors in a social scene maintained neutral facial expressions. It further aimed to assess for the first time the gaze-following mechanism in SA.

Our results are the first to demonstrate how attentional biases develop over time in HSA individuals in a naturalistic, neutral social scene. HSA participants allocated more attention to the face than those with low SA, during the first two seconds of the scene. However, there were no differences in the number of first fixations landing on the face between the groups and the time to first fixate the face was equivalent between groups. However we did find that where the first fixation was to the face, the HSA participants' fixation durations were significantly shorter than those in the LSA group. However, there were no differences between the groups' general eye movement characteristics (fixation duration, fixation number, scanpath length) or social viewing behaviour in the remainder of the task, with the majority of fixations directed towards faces in both groups.

If we accept the operationalised definitions of attentional components (Armstrong & Olatunji, 2012), our results do not appear to support a hypervigilance of social attention in the HSA group: we found no group difference in proportion of first fixations to faces which also did not differ in latency. Despite this, increased subsequent fixations to faces in the HSA group suggest maintenance of attention, that is, a failure to disengage fixations from this most salient social stimulus. This persisted only in the early phase of the scene (2 seconds), with viewing behaviour equivalent thereafter, with faces fixated more than any other region, regardless of social anxiety levels which is consistent with the previous study using this task with nonclinical participants (Gregory et al., 2015).

This increased early bias towards faces concords to an extent with results of Waechter et al.'s (2014) time-course analysis, which although involved only static images, found a dwell time bias towards (angry) faces in HSA participants between 1000 and 2000ms. However, contrary to a number of previous studies (Chen et al., 2015, 2002; Mansell et al., 1999) we found little evidence of avoidance of faces in the HSA group, which might be accounted for in part by the neutral valence of our social stimulus, or alternatively our interpretation of *avoidance*. If we based all of our interpretations upon first fixation parameters (Armstrong & Olatunji, 2012; Garner et al., 2006) we could interpret the shorter first fixation durations on the face in the HSA group as avoidance. Clearly this would make little sense in the context of the other results presented here which show a clear, initial bias towards the face in the HSA group followed by equivalent eye movement behaviour between groups thereafter, taken from multiple eye movement measures. This highlights the vulnerability of data to misinterpretation, particularly when only a limited number of parameters are analysed. Rather than avoidance per se (these participants were after all, looking at the face within a complex scene in their first fixation), the shorter first face fixations of the HSA group may well reflect faster processing of this potentially aversive stimulus. It is possible that all that needs to be gleaned from the face of a stranger can be achieved in far shorter a time by individuals who are socially anxious if that face may pose a potential threat. This could be considered in some way to reflect hypervigilance of a sort. That shorter fixation durations over the whole trial were not a feature of the HSA group, demonstrates that whatever was driving this early difference subsided over time, as with our other measures, and was therefore not a feature of a general cognitive or physiological difference between the groups. Similarly, we did not find any evidence for the hyperscanning viewing strategy reported elsewhere. Participants' total scanpath lengths, saccade amplitudes, number of fixations as well as the previously mentioned fixation durations were equivalent between groups. The reason for this may be the neutral valence of the scene and/or the limited number of actors present. The most comparable study to the current research presented participants with an array of faces which gave positive, negative or neutral facial feedback to participants dynamically over the trial (Chen et al., 2015). In such a scenario, scanning from face to face would be expected if participants were continually monitoring for threat. In our stimulus, as the two individuals sat close to one another, it may have been possible for ongoing threat detection to occur without the need for continuous scanning of the scene.

To summarise, our data support an early bias towards faces in SA, with potentially faster processing of the face in the first fixation, which might support a maintenance hypothesis, but we found little evidence for either hypervigilance or avoidance by current definitions.

The processing of neutral social stimuli in SAD has been largely overlooked in previous research. But our results concord to an extent with those of Garner et al. (2006) who showed that under low stress conditions, HSA individuals were biased towards rather than away from neutral, static faces compared to objects. In addition, Chen et al. (2015) showed that even in a higher stress scenario and over longer periods (50sec), SA did not modulate gaze behaviour when the dynamic stimuli were emotionally-neutral, which is consistent with our full video analysis. Taken together, our results suggest that SA causes an additional, early prioritisation of faces, which returns to typical levels over time. Given this occurred within a neutral scenario, a possible explanation is that initially gaze was biased to faces to monitor for threat and when none was detected, this bias diminished. The results from the current study, which were obtained under low stress conditions may add further to the suggestion that social stress may impact on the direction of attentional biases, as avoidance of faces has only emerged in previous studies under high stress conditions and typically with negative stimuli (Chen et al., 2015; Garner et al., 2006; Mansell et al., 1999). This clearly requires further investigation as we did not manipulate either emotion of the stimuli or stress within the current study.

Our results provide no evidence for differences in gaze-following in SA. All participants overtly followed the gaze shifts around 30% of the time and spent more time attending to the gazed-at targets after the gaze shift than before, suggesting a gaze-induced shift of overt attention. To our knowledge the current paradigm is the only one to be employed to examine naturalistic gaze following (Gregory et al., 2015). The phenomenon has been previously investigated using the gaze cueing paradigm (Driver et al., 1999; Kuhn & Benson, 2007) where any effect of gaze is only attentional (faster processing of the cued location) rather than behavioural, as participants rarely make overt eye movements in the direction of these cues in such tasks (Gregory & Hodgson, 2012; Kuhn & Benson, 2007). Not even this gaze cueing effect has been previously studied in social anxiety, although one study with participants with generalised anxiety suggested those participants were more influenced by the gaze cues of fearful faces (Fox et al., 2007). As our stimuli were neutral, rather than threatening, this may provide an explanation for our different results. However, many researchers have questioned the validity of the gaze cueing paradigm citing concerns of poor ecological validity leading to a paradigm which may have little social relevance at all (Gregory et al., 2015). This issue can be no more pertinent than when considering it in terms of behaviour in social anxiety where the social context is the critical variable. It has recently been suggested that overt gaze following of the sort examined here may be impervious to top-down influences and individual differences and may instead represent an automatic oculomotor stimulus-response association developed early in life from repeated exposure to the stimulus and the rewarding consequences of attending to it (Cole, Smith, & Atkinson, 2015; Gregory, Hermens, Facey, & Hodgson, 2016). As one previous ERP study showed differences in neural responses in those high in SA in response to averted eye gaze (Schmitz et al., 2012), future studies might consider examining the reward value placed on gazed-at objects by participants rather than the orienting response per se when investigating potential differences between groups in this behaviour.

Limitations, Future directions and Clinical implications

The current paradigm can be adapted to further probe the conditions under which these attentional biases in SA occur. Future research should assess the influence of emotional context and stress on the direction of attentional biases and further explore our suggestion for investigating more subtle differences in gaze following behaviour. Whilst a core strength of this study is its novel approach, the merit of this must be weighed against the relatively small sample size included in the analyses. This was due to participants scoring within the interquartile range of social anxiety being excluded in order to achieve high and low scoring groups. In an underpowered study there is a decreased likelihood of detecting small effects and an increased risk of Type II and Type I errors (Christley, 2010) together with the possibility of inflated effect sizes (Gelman & Weakliem, 2009). Particularly pertinent to the current study, we found several null effects which have the potential to be the results of Type II errors. Although the effects we anticipated based on the previous available research were moderate rather than small (Armstrong & Olatunji, 2012)it is still possible that the suboptimal power of the study failed to detect genuine effects. In order to add further support to our results and in line with the continuing discussion within the scientific community about the (lack of) replicability of research (Lindsay, 2015; Munafò et al., 2017; Open Science Collaboration, 2015), a larger scale replication of this study would be beneficial.

Our results suggest that HSA individuals may struggle to disengage attention from faces in neutrally valenced social situations, when those with LSA have already shifted their attention away from the face. This may mean that those with HSA might be more likely to notice delayed or fleeting negative facial expressions, which LSA people would miss and therefore be untroubled by. Additionally, this may result in HSA individuals performing less well socially, due to missing important relational information in the form of body language such as posture (de Gelder, 2009). As well as generating anxiety in social situations, failure to disengage from faces may also make social competency more difficult. The likely negative impact of safety behaviours on social competency has been addressed in several accounts of SAD (Clark & Wells, 1995; Wong & Rapee, 2016). However, the potentially unhelpful impact of socio-attentional factors such as difficulty in disengaging attention from faces has not, to date, been addressed in models of SAD or tested empirically. These effects should be investigated in help-seeking SAD samples, and if found to be relevant, attentional guidance and practice could be used to alter these biases and any negative outcomes associated with them. Attentional training as an adjunct to more established psychosocial interventions has already shown some promise (Fistikci et al., 2015) and the findings of the current study may lead to improvements in this approach.

Conclusion

Our primary aim in this study was to assess the hypervigilance, avoidance and maintenance hypotheses of attentional bias in SAD, but in doing do we highlighted inconsistencies in operationalising these components. Although we found that HSA individuals fixated more on faces in the early stages of our task, we are reluctant to interpret this too definitively as vigilance or maintenance of attention, given the lack of consensus around definitions. It may therefore be more fruitful, here and in future work, to interpret findings in terms of the direction and duration of attentional biases more objectively rather than via poorly defined concepts.

However, one consistency in previous SAD research appears to be the almost exclusive use of static stimuli, which is surprising given the dynamic processes under investigation. This was a limitation which we began to address here. However, if cognitive psychology is to have a meaningful impact on treatment of SAD, it should strive to conduct research which genuinely reflects real-life social experiences of sufferers. This is an important endeavour because a substantial minority of people with SAD do not respond to the current, most effective treatments (Acarturk, Cuijpers, van Straten, & de Graaf, 2009; Davidson et al., 2004). Looking outside traditional experimental methods is a solution worthy of serious consideration.

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Disclosure statement

The authors report no conflicts of interest