The effect of social anxiety on top-down attentional orienting to emotional faces

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Abstract

One of the fundamental factors maintaining social anxiety is biased attention toward threatening facial expressions. Typically, this bias has been conceptualised as driven by an overactive bottom-up attentional system; however, this potentially overlooks the role of top-down attention in being able to modulate this bottom-up bias. Here, the role of top-down mechanisms in directing attention toward emotional faces was assessed with a modified dot-probe task, in which participants were given a top-down cue ("Happy" or "Angry") to attend to a happy or angry face on each trial, and the cued face was either presented with a face of the other emotion (angry, happy) or a neutral face. This study found that social anxiety was not associated with differences in shifting attention toward cued angry faces. However, participants with higher levels of social anxiety were selectively impaired in attentional shifting toward a cued happy face when it was paired with an angry face, but not when paired with a neutral face. The results indicate that top-down attention can be used to orient attention to emotional faces, but that higher levels of social anxiety are associated with selective deficits in top-down control of attention in the presence of threat.

Keywords: selective attention, spatial attention, social anxiety, dot-probe, threat bias.

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In life, we are bombarded with visual information, only a small amount of which we can process. A key function of the attentional system is to filter information, separating relevant input from input that can be ignored. In the literature, an attentional bias for threatening facial expressions has been found among socially anxious individuals (Grafton & MacLeod, 2016; Lin, Hofmann, Qian, Kind, & Yu, 2016; Mogg & Bradley, 2002; Mogg, Philippot, & Bradley, 2004; Pishyar, Harris, & Menzies, 2004; Schofield, Johnson, Inhoff, & Coles, 2012). For instance, Lin and colleagues (2016) found that, when giving a speech, participants with high levels of social anxiety spent longer looking at audience members displaying negative facial expressions and less time looking at audience members displaying positive facial expressions than did participants with low levels of social anxiety. Research indicates that attentional bias towards threat is an important factor in the maintenance, and perhaps even causation, of anxiety (MacLeod & Mathews, 2012; MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002; Rapee & Heimberg, 1997; Van Bockstaele et al., 2014). While it is true that some studies have not found evidence for a threat bias associated with social anxiety, these tend to be the exception rather than the rule, and there are typically methodological differences in these studies (e.g., long stimulus presentation times of 1000ms) that could account for not observing the bias in these cases (Gotlib et al., 2004, Bradley et al., 1997; Pineles & Mineka, 2005). Moreover, at times, individuals with high levels of social anxiety also appear to have a bias *away* from threat, though this has been associated with methodological differences in the type of paired image (e.g., inverted faces or household items) (Boal, Christensen, & Goodhew, 2018; Chen, Ehlers. Clark, & Mansell, 2002). Both enhanced engagement with threat and avoidance of threat are conceptualised as reflecting the temporal dynamics of the atypical attentional processes that characterise anxiety (Cisler & Koster, 2010; Zvielli, Bernstein, & Koster, 2014). Altogether, the literature indicates that individuals with high social anxiety have atypical attentional processing patterns in the presence of threatening information, which is most often observed as a bias toward threat. To develop treatments that may break the reinforcing loop between this threat bias and increasing levels of social anxiety, it is essential to understand the underlying attentional processes driving this threat bias. Therefore, the present study applied key theoretical concepts from the attention literature to understand the nature of the threat bias in social anxiety; namely, whether biased attention is associated with top-down attention, bottom-up attention, and/or selection history. (Note that when we use the term *social anxiety* throughout, we are referring to a construct assumed to exist as a dimension on which individuals in the population vary and for which high levels may, but do not necessarily invoke a diagnostic category).

A core distinction that resonates throughout the attention literature is that between top-down and bottom-up attention (e.g., Corbetta & Shulman, 2002). Top-down attention refers to the voluntary allocation of attention toward particular objects, features, or spatial locations based on one's current goals (e.g., searching for a friend's red hat in a crowd). In contrast, bottom-up attention is an involuntary, rapid, and inflexible process that selects visual information based on the salience of stimulus features (e.g., a red object amongst green distractors). In addition, a third attentional mechanism has recently been recognised; that of selection history (Awh, Belopolsky, & Theeuwes, 2012). Selection history is attentional capture due to past selection or past reward history of a visual stimulus, even if it no longer matches an individual's top-down goal. Selection history is considered distinct from either top-down or bottom-up processes (Awh et al., 2012). Below, we review evidence for the threat bias associated with social anxiety, discussing the possibility that it is linked with impaired top-down attentional control.

At present, the processes mediating biased attention toward threat remain relatively unknown. The normative attention literature informs us that top-down attention is a powerful mechanism that can override the attentional capture by salient stimuli. For example, while a unique-onset stimulus appearing in a display typically captures attention via bottom-up mechanisms, this capture can be overridden if an individual is instead searching for a differently-coloured target, as the onset does not match their top-down attentional goal (Folk, Remington, & Johnston, 1992). The influence of top-down attention over attentional orienting has also been demonstrated for emotional faces (Barratt & Bundesen, 2012). Barratt and Bundesen (2012) found that attentional capture by task-irrelevant negative faces depended on whether the task-relevant stimulus was a face or not, which presumably led to different top-down attentional goals. More specifically, in one experiment, participants were instructed to respond to the identity of a central schematic face surrounded by distractor faces. Reaction times (RTs) were slower for positive face targets when they were flanked by negative faces compared with positive or neutral faces, indicating involuntary capture of attention by negative faces. However, when the central target was a letter instead of a face, there was no such RT slowing, indicating that participants' attention was no longer captured by the negative face distractors. This suggests that spatial attentional capture by negative faces can be modulated by top-down attention (i.e., whether or not one was looking for a face target).

The above-reviewed empirical examples suggest that bottom-up attentional capture by threatening or otherwise-salient stimuli can be overridden by top-down control of attention. However, there are also theoretical reasons to believe that voluntary attentional control may be impaired among individuals with anxiety. For example, Attentional Control Theory (Eysenck, Derakshan, Santos, & Calvo, 2007) posits that anxious individuals have an imbalance between top-down and bottom-up attention, with increased influences from bottom-up capture of attention and poorer top-down control. According to this model, as a result of reduced attentional control, anxious individuals are more likely to have difficulty inhibiting attention toward task-irrelevant stimuli, shifting attention between tasks, as well as updating information (e.g., reading and operation spans), particularly in stressful situations.

A similar account has been proposed by Bishop, Jenkins, and Lawrence (2007), who manipulated perceptual load to examine the role of top-down attention in the processing of threatening stimuli for individuals with varying levels of state and trait anxiety. That is, compared with high perceptual load conditions, under low perceptual load, participants have a greater availability of spare attentional resources and so top-down attention is required to regulate attention and prevent it from being directed to salient, but task-irrelevant stimuli such as threat. Bishop et al. (2007) presented participants with a string of six letters superimposed on the image of a face, which either had a fearful or neutral expression. Participants' task was to identify whether the letter string contained an "X" or an "N". The faces were therefore always task-irrelevant. High perceptual load was induced by presenting the target X/N amongst 5 nontarget letters (H, K, M, W, Z), whereas low perceptual load was induced by presenting a homogenous string of six Xs or Ns. Bishop et al. (2007) found that under low perceptual load, anxious participants exhibited a pattern consistent with enhanced allocation of attention to the task-irrelevant threatening stimuli and reduced top-down control. More specifically, under conditions of low perceptual load, state anxious participants displayed heightened Blood Oxygenation Level Dependent (BOLD) responses in the amygdala and superior temporal sulcus triggered by task-irrelevant fearful facial expressions, and trait anxious participants displayed reduced BOLD responses in prefrontal regions associated with top-down attentional allocation of resources. Bishop et al. (2007) concluded that elevated trait anxiety is associated with poorer recruitment of top-down attention, which is necessary for ignoring the distracting faces. More recent research has also found that anxiety is associated with impoverished recruitment of frontal cortical regions implicated in attentional control on tasks with non-emotional stimuli (Bishop, 2009).

In sum, previous research converges on the conclusion that trait anxiety is associated with deficits in top-down control, thus resulting in bottom-up biases operating unchecked. However, given the focus of previous research, there is still an important gap in the literature. That is, Bishop et al. (2007) employed centrally-presented faces. This means that attentional shifts through space, which are central to models of biased attention, were not necessary in these tasks. Furthermore, participants' ability to use goal-directed attention to orient attention to emotional faces was not directly measured. Finally, Bishop and colleagues' (2007) population of interest was state and trait anxiety, rather than social anxiety. While there is, of course, overlap between trait anxiety and social anxiety, they are theoretically distinct. Therefore, the aim of the current study was to investigate the manner in which individuals who are higher in trait-level social anxiety differ in their capacity to exert attentional control in the context of emotional stimuli, as compared to individuals lower in social anxiety. This was done in a context where spatial attentional shifts were directly manipulated.

We also sought to distinguish between two alternative accounts. One is that, relative to those lower in social anxiety, socially anxious individuals could suffer from a general deficit in attentional control, which would be revealed as an impairment in orienting attention in response to all top-down cues. The alternative is that socially anxious individuals could have a more selective deficit, such that an impairment in using top-down attention is revealed only in the presence of competing threatening information. In other words, top-down attentional deficits would manifest only when the bottom-up signal was particularly potent.

To test these accounts, the current study employed a modified dot-probe paradigm with emotional photographic faces. In a standard dot-probe task, participants initially fixate on a central fixation cross. A pair of images of different valences is then presented, usually one to the left and one to the right of fixation. These stimuli then offset after a short period of time (e.g., 500ms) and a target probe (e.g., the letter E or F) replaces one of the images and participants are instructed to respond to its identity (or detect its presence or location in some cases) as quickly and accurately as possible. Faster responses to the probe when it replaces a threatening image (e.g., an angry facial expression) compared with a neutral image (e.g., neutral facial expression) are considered to reflect an attentional bias toward threat (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; Macleod, Mathews, & Tata, 1986). The modification of the standard dot-probe paradigm employed here was to add explicit top-down cues at the beginning of each trial, that indicated to which face participants should attend. By adding these cues, participants were given a top-down goal on each trial to attend to a particular facial expression. This, therefore, tested participants' ability to exert top-down attentional control and shift attention to the cued expression and inhibit attentional capture by the distractor face. The cue was valid (i.e., predicted the location of the subsequent target) on most, but not all of the trials. Participants' ability to use the cue is measured by the difference in RT for the valid compared with the invalid trials (i.e., a cueing effect). No difference in RT between these trials (i.e., no cueing effect) would suggest that no attentional shift occurred in response to the cues, whereas faster responses on valid compared with invalid trials (i.e., a cueing effect) indicates that participants shifted their attention in response to the cue.

The dot-probe paradigm was employed because, rather than using a single centrally-presented image (e.g., as per the flanker task), the dot-probe paradigm entails the presentation of two competing images. This more accurately gauges the theoretical process of interest: *shifts* of attention across space. This also has ecological validity as, for example, when an individual with social anxiety gives a speech, he or she may make attentional shifts to different audience members and attend to those with bored or critical expressions rather than those with encouraging expressions.

An important issue when measuring top-down attention is that it can be confounded by effects of selection history. Selection history refers to instances where visual attention is captured based on one’s past selection and reward history (Awh et al., 2012). In an early demonstration of selection history, Maljkovic and Nakayama (1994) conducted a pop-out visual search task in which participants made speeded responses to a target defined by colour or spatial frequency cues. Faster RTs were found when the same target repeated across two trials, compared with when it switched. In fact, this speeding of responses occurred even when participants knew with 100% certainty the identity of the target on the upcoming trial, indicating that selection history can guide attention even when it differs from one’s current goal (Belopolsky & Awh, 2016; Theeuwes, Reimann, & Mortier, 2006; Theeuwes & Van der Burg, 2013). Since some researchers have theorised that selection history may independently contribute to threat biases (Peschard & Philippot, 2016), it was also studied in the current experiment by examining participants’ ability to orient to the cued facial expression separately for trials in which the target repeated from the previous trial, compared with when it switched.

To summarise, the current study measured social anxiety, and quantified top-down control by measuring cueing effects for happy or angry face cues provided on each trial that directed participants to attend to particular facial expressions. Previous theory and research indicate that anxious individuals have deficits in top-down control, and this can occur in the presence of threatening stimuli as well as non-emotional stimuli. Therefore, two competing hypotheses were tested: (1) participants with higher levels of social anxiety will demonstrate reduced cueing effects when orienting to a happy face paired with a distracting angry face, but will have similar cueing effects in other conditions, or (2) participants with higher levels of social anxiety will demonstrate reduced cueing effects in all conditions, regardless of the presence or absence of threat.

Method

Participants

One-hundred and ten participants were recruited via the Australian National University online sign-up portal and online Australian National University advertising portals. Ethical approval was provided by the Australian National University Human Research Ethics Committee (protocol number: 2014/534). Participants provided written, informed consent. The sample size was determined based on GPower calculations[1]; using the ANOVA function (repeated-measures, between-factors, a priori) with power of 0.9 and an effect size *f* of 0.25 (medium effect). This calculation yielded a recommended sample size of 98 (note that, after participant exclusions, the sample size of the current study was 99 participants). Restrictions were that participants were Caucasian (to match the ethnicity of the face stimuli), aged 18-30 years (to ensure the sample consisted only of young adults, given age-related changes in vision and cognition that may affect task performance), with normal or corrected-to-normal vision. Participants' ages ranged from 18 to 30 years (M = 19.88, SD = 2.61), 4 participants were left-handed, and 34 were males and 76 were females. Participants were offered one hour of course credit or $15 (AUD).

Experimental Stimuli and Apparatus

This experiment was conducted in a dimly lit room. Stimuli were presented on a liquid crystal display monitor running at a 60Hz refresh rate. Viewing distance was set with a chinrest at 44cm. Stimuli were programmed in Matlab using the Psychophysics Toolbox (Brainard, 1997). The background was set to black. On each trial, the word cue could be

[1] We note that GPower does not provide a direct computation for a 2x2x2 factorial repeated-measures ANOVA with a continuous between-subjects predictor. Instead, we used this function as the closest approximation to the current study's design.

“Happy” or “Angry”, which was presented in white, size 18 Helvetica font. Similarly, the probe employed on each trial was either an “E” of “F” and was presented in white, size 18 Helvetica font.

Images of faces were taken from the NimStim database (Tottenham et al., 2009). These consisted of Caucasian faces posing with closed-mouth neutral, happy, and angry expressions. Closed-mouth expressions were chosen to eliminate bottom-up attentional capture by teeth (Horstmann, Lipp, & Becker, 2012). Caucasian images were employed to control for the cross-race effect (for a review, see Young, Hugenberg, Bernstein, & Sacco, 2012), as other-race faces can be processed differently to faces of one’s own race. Further exclusions were made due to the incorrect size of one of the images (model 1), confounding facial hair (model 31), and not having a closed-mouth happy face image (model 27). Therefore 22 models (7 females and 15 males) were included, each with three associated images of happy, neutral, and angry expressions. During the experiment, each image subtended approximately 9.4° x 12.1° of visual angle, with a gap of 9.4° of visual angle between the two presented images.

Questionnaires

Participants also completed two questionnaires to measure psychopathology. Firstly, to assess social anxiety, the self-report version of the Liebowitz Social Anxiety Scale (LSAS; Liebowitz, 1987) was employed. This 24-item scale assesses fear and avoidance of social situations. Ratings are made on two 4-point Likert-type scales, with fear rated from 0 (“none”) to 3 (“severe”) and avoidance rated from 0 (“never, 0%”) to 3 (“usually, 68%-100%”). A total score can be calculated by summing scores from both the fear and avoidance scales (maximum = 144). This measure was selected for its good psychometric properties (Baker, Heinrichs, Kim, & Hofmann, 2002; Fresco et al., 2001; Levin, Marom, Gur, Wechter, & Hermesh, 2002; Oakman, Van Ameringen, Mancini, & Farvolden, 2003; Rytwinski et al., 2009), brevity and ease of administration, and thorough conceptualisation of social anxiety, including overall and subscale social anxiety scores. In the current study, Fear subscale scores ranged from 5 to 64 (*M* = 28.25, *SD* = 12.12), Avoidance subscale scores ranged from 2 to 60 (*M* = 25.95, *SD* = 12.80), and total scores ranged from 9 to 120 (*M* = 54.47, *SD* = 24.56). Here, the total scores were used to operationalise social anxiety. These total scores are higher than those obtained by Caballo, Salazar, Irurtia, Arias, and Nobre (2013) who, with a large university sample, found a mean LSAS-SR score of 42.19 for males and 45.73 for females.

Although not directly important for the study, generalised anxiety and depression were measured to provide a more informed characterisation of the sample. To achieve this, the Depression Anxiety Stress Scale-21 (DASS-21) was employed. Across 21-items, participants are asked to rate the degree to which each symptom has applied to them over the past week. Ratings are made on a 4-point Likert scale from 0 (never) to 3 (almost always). Separate scores are calculated for depression, anxiety, and stress, each ranging from 0 to 42. The DASS-21 has been found to have good convergent, discriminant, and construct validity (Crawford & Henry, 2003; Henry & Crawford, 2005; Lovibond & Lovibond, 1995) and reliability (Antony, Bieling, Cox, Enns, & Swinson, 1998; Brown, Chorpita, Korotitsch, & Barlow, 1997; Crawford & Henry, 2003; Lovibond & Lovibond, 1995). The Depression scores ranged from 0 to 42 (*M* = 10.20, *SD* = 8.87), anxiety ranged from 0 to 34 (*M* = 8.48, *SD*=7.90), and stress ranged from 0 to 40 (*M* = 13.99, *SD* = 9.39).

Procedure and Design

On each trial, a pair of faces was presented, and each face could appear on either the left or the right side of the screen. The conditions included happy-neutral, happy-angry, and angry-neutral pairings. It was always either the happy or angry face that was cued, either validly (the probe was in the cued location) or invalidly (the probe was in the location of the non-cued face). Thus, the design was 2 (target expression: angry or happy) x 2 (distractor expression: emotional or neutral) x 2 (validity: valid or invalid) design.

An additional "Incorrect cue" condition was included. Here, pairs of faces were happy-neutral or angry-neutral. The cue did not match the faces presented, and the probe appeared in the locus of the emotional expression. This was included as an exploratory condition to test where participants' attention would be allocated when the cued expression was not present. For example, if participants received a cue of "happy" but were then presented with an angry-neutral face pair, would their attention be captured by the un-cued angry face or would they only attend to emotional faces that match their top-down goal? The incorrect cue condition was not part of the main factorial analysis but was analysed separately, since it did not have a corresponding valid condition.

In this study, participants completed the demographic questions, the computer task, and then the LSAS and DASS-21. The computer task included an initial 50 practice trials and then 360 experimental trials with 8 rest breaks. Trials were randomised throughout the experiment with the constraint that the cued face was predictive of the probe location on 75% of trials. An equal number of happy-target and angry-target trials were included. On each trial, the two expressions presented were taken from the same model so that the images were matched for facial properties. The identity of the face on each trial was randomly selected with the constraint that the same proportion of male and female images were included in each condition.

On each trial, participants were presented with a black screen with a central fixation cross for 500ms (see Figure 1). The cue word, written in the centre of the screen ("Angry" or "Happy"), was then presented for 1000ms and was followed by a black screen with a fixation cross for 1000ms. Participants were instructed to orient their attention to the cued facial expression when it appeared and that doing so would help them perform the task more quickly. The faces were presented for 200ms, one to the right and one to the left of fixation. After they offset, a probe (the letter “E” or “F”) was presented for 300ms in the locus of one of the faces (equally likely to be each letter and equally likely to appear on the left or the right of the screen). Participants were asked to indicate the identity of the probe (an E or F), with a keyboard press as accurately and quickly as possible (“z” and “/” keys were marked as “E” and ‘F” on the keyboard, respectively). Once participants made a keyboard press, the next trial began. RTs were measured as the duration between the onset of the probe letter and participants’ key press.

Although 500ms image presentation is the most commonly employed duration in the literature, a 200ms duration was selected in the current study so as to minimise participants’ ability to make saccades in that timeframe. In addition, during pilot testing, participants reported that they were able to consciously perceive images at 200ms but not at quicker presentations. The probe presentation of 300ms (as opposed to visible until response) was selected during pilot testing to encourage participants to make quick attentional shifts (so as not to miss seeing the probe).

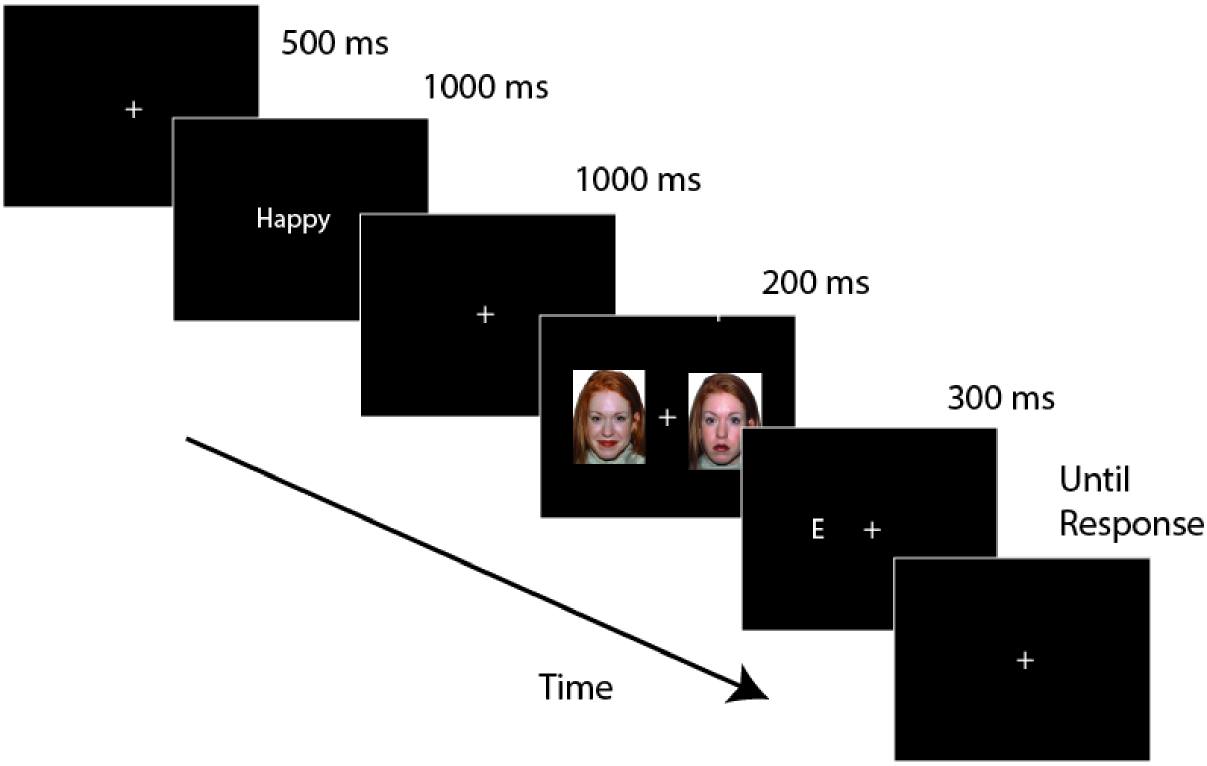

Figure 1. Schematic of a trial. This is an example of a valid trial, in which participants receive a “Happy” cue and then view a happy face paired with a neutral face and the probe appears in the locus of the happy face. Note that consent to use these particular face images for research and reproduction for publication was granted by Nim Tottenham to Hannah Boal (now Delchau) via email on July 9, 2016.

Results

Data Analysis

Data from five participants were excluded for having chance-level accuracy on the dot-probe task and data from six participants were excluded as RTs were outliers (z-score > 3.29). Therefore, data from 99 participants were included in the analyses. Trials in which participants made an invalid key press (i.e., hit a key that was not ‘E’ or ‘F’) or responded quicker than 100ms or slower than 2.5 standard deviations from their average RT were also excluded, consistent with previous research using RT (e.g., Goodhew, Freire, & Edwards, 2015; Goodhew & Plummer, 2019; Lester et al., 2019; van den Herk et al., 2012; Yoon et al., 2017). This accounted for on average 2.33% of participants' data. Accuracy and RTs for the correct trials were then calculated. Mean accuracy on the probe task was 90.85% (*SD* = 5.69%) and RT was 661.14ms (*SD* = 106.07ms). Since social anxiety is considered a continuous variable in the population, it was measured and analysed as continuous in the current study (see DeCoster, Iselin, & Gallucci, 2009). Furthermore, to increase interpretability and reduce multicollinearity, each participant's social anxiety score was centred around the grand mean (see Tabachnick & Fidell, 2013). Raw data can be found here[1]: https://osf.io/unzw4/.

Accuracy. While RT was the primary measure of interest, accuracy was also examined to assess for any potential speed-accuracy trade-offs. To assess accuracy data, a 2 (target expression: happy or angry) x 2 (distractor expression: neutral or emotional) x 2 (validity: valid or invalid) ANCOVA was conducted with the continuous predictor variable of social anxiety. The effect of target expression was not significant, $F(1, 97) = 3.59$, $p = .061$, $\eta_p^2 = .036$, Cohen's $d = .39$[2]. There was, however, a significant interaction between target expression and validity, $F(1, 97) = 5.36$, $p = .023$, $\eta_p^2 = .052$, $d = .47$. A subsequent ANCOVA with one RM factor (validity: valid versus invalid) was performed with the continuous predictor of social anxiety on (a) average accuracy for when the target face was happy, and (b) average accuracy for when the target face was angry. This revealed that when the target face was happy, there was no significant difference in accuracy between the valid versus invalid trials ($F<1$, $d = .06$). In contrast, when the target was angry, there was a significant main effect of validity, $F(1, 97) = 8.10$, $p = .005$, $\eta_p^2 = .077$, $d = 0.58$, such that responses were on average more accurate for invalid ($M = 92\%$) versus valid ($M = 91\%$) trials. No other effects were significant (*p*s > .269, *d*s < .23).

Reaction time. Only trials on which participants correctly identified the probe were included in the RT analysis. To analyse the RT data, a 2 (target expression: happy or angry) x

2 (distractor expression: neutral or emotional) x 2 (validity: valid or invalid) ANCOVA was conducted with the continuous predictor variable of social anxiety. A main effect of validity was found, $F(1, 97) = 34.18$, $p < .001$, $\eta_p^2 = .261$, $d = 1.19$, as participants were quicker on the valid trials (M = 657 ms) compared with the invalid trials (M = 676 ms). This greater response efficiency for valid trials held when the dependent variable was an inverse efficiency score (IES), instead of RT, to account for the slight increase in accuracy observed on the invalid trials (IES = RT / (1 - proportion of errors, see Townsend & Ashby, 1978, 1983; for a discussion see Bruyer & Brysbaert, 2011). This demonstrates that participants complied with the instructions to use the top-down cue, and that this was effective in orienting their spatial attention.

The key theoretical question was whether participants with social anxiety would either have reduced attentional control, or whether any deficit would be selective to when threatening information serves as the distractor. Generic reductions in top-down control would be evidenced by reduced orienting in response to the top-down cue irrespective of the cued or distracting facial expression, as indicated by an interaction between social anxiety and validity. The selective deficit would instead be evidenced by reduced orienting to the cued expression when the distracting face was threatening (unique to when the *happy* face was cued and the non-target paired stimulus was *angry*), as indicated by a higher-order interaction between social anxiety, validity, distractor expression, and target expression. The interaction between validity and social anxiety was not significant ($F < 1$, $d = .06$). There was, however, a significant four-way interaction among target expression, distractor expression, validity, and social anxiety, $F(1, 97) = 7.14$, $p = .009$, $\eta_p^2 = .069$, $d = .54$. The effects of distractor expression, validity, and social anxiety was then assessed separately for each target expression (i.e., happy or angry).

For *angry-target faces*, there was a validity effect, $F(1, 97) = 24.31$, $p < .001$, $\eta_p^2 = .200$, $d = 1.0$, with faster RTs on valid (M = 658ms) compared with invalid trials (M = 677ms). No other main or interaction effects were indicated ($ps \geq .438$ and ds < .16 for interactions with social anxiety). In addition, an analysis with IES scores confirmed that responses were significantly more efficient for valid than for invalid trials. Altogether, this suggests that social anxiety was not associated with differences in attending to the angry faces, and instead all participants were able to use top-down attention to orient their attention to the angry faces.

However, for *happy-target faces*, a three-way interaction was revealed among the factors distractor expression, validity, and social anxiety, $F(1, 97) = 9.38$, $p = .003$, $\eta_p^2 = .088$, $d = .62$. To disentangle this three-way interaction, the effects of validity and social anxiety and their interaction were assessed separately for the two different distractor expressions (angry or neutral) presented with the happy face targets. This showed that for happy-neutral face pairs, there was a significant effect of validity, $F(1, 97) = 11.04$, $p = .001$, $\eta_p^2 = .102$, $d = 0.67$, with faster RTs for valid trials (M = 655ms) compared with invalid trials (M = 673ms). The interaction between validity and social anxiety was not significant, $F(1, 97) = 3.27$, $p = .074$, $\eta_p^2 = .033$, $d = .57$, indicating that all participants demonstrated an equivalent cueing effect irrespective of level of social anxiety.

In contrast, analyses revealed an overall validity effect for happy-angry trials, $F(1, 97) = 16.80$, $p < .001$, $\eta_p^2 = .148$, $d = .83$, with faster RTs for valid trials (M = 657ms) compared with invalid trials (M = 678ms), as well as a significant interaction between validity and social anxiety, $F(1, 97) = 5.34$, $p = .023$, $\eta_p^2 = .052$, $d = .47$. To illustrate this interaction, a cueing score was calculated for each participant as: invalid RT *minus* valid RT (where scores above zero indicate that participants could shift attention toward the cued happy face). As shown in Figure 2, participants with higher levels of social anxiety had lower cueing scores, indicating that they had difficulty shifting attention to the cued happy face on happy-angry trials. Indeed, a significant negative Pearson correlation was found between social anxiety and the cueing score for happy cued faces on happy-angry trials, $r = -.29$, $p = .023$, $d = .61$.

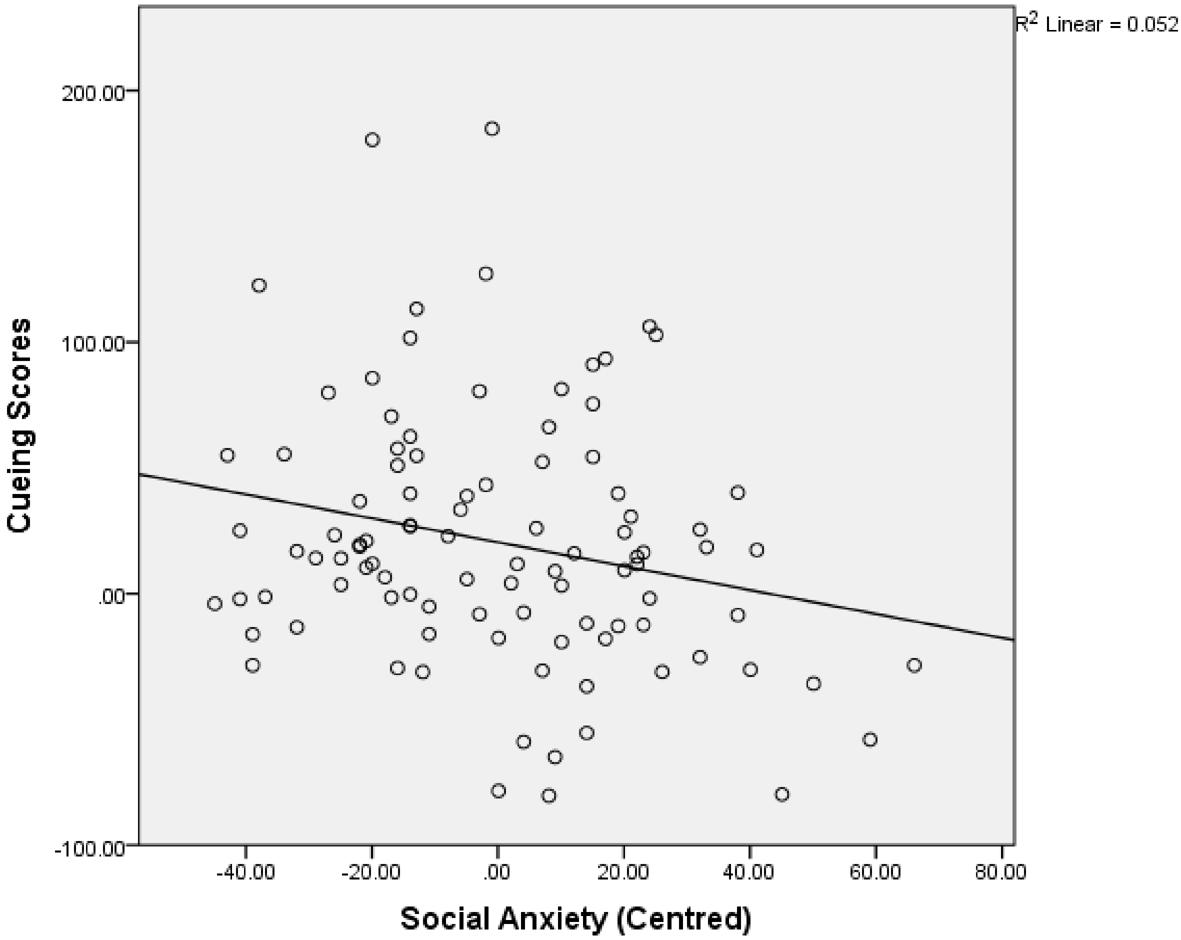

Figure 2. The relationship between social anxiety (centred) (x-axis) and cueing scores (in ms) (y-axis) toward cued happy faces on happy-angry face trials.

The psychometrics of the social anxiety score were reported in the methods section, but the reliability of the dot-probe is less well-established. A reasonable estimate of reliability can be obtained by comparing scores from one half of trials to the other (see Goodhew & Edwards, 2019, for practical recommendations). Here, we computed values for the first and second half of trials and submitted these to a 2 (half) x 2 (target expression) x 2 (distractor expression) ANCOVA with social anxiety as the continuous covariate. This revealed that there was a main effect of half, such that RTs were quicker in the second half versus the first half of trials, reflecting a generic and commonly-observed order effect. Order did not interact with any other main effects or interactions, whereas both the main effect of validity ($p < .001$) and the four-way interaction among target expression, distractor expression, validity, and social anxiety ($p < .028$) remained significant. In other words, the pattern of results was stable between the first and second half of trials. Similarly, even when the cueing scores (difference scores) plotted in Figure 2 were the dependent variable, experiment half yielded no reliable effect ($p = .174$), indicating that these scores were stable across the experiment. This is quite reassuring, given the evidence for some dynamic components to attentional bias scores (see Cox, Christensen, & Goodhew, 2017; Zvielli, Bernstein, & Koster, 2015), which can undermine aggregate-score level reliability. It could be that the specific instructions employed in the modified version of the dot-probe here (i.e., instructions to attend to a specific face, rather than passive viewing of faces) may contribute to improved reliability of the task.

Figure 2 shows that there is an inverse relationship between social anxiety and cueing toward happy faces in the presence of an angry face distractor. However, it would be useful to understand more precisely how this cueing effect is affected at different levels of social anxiety. To this end, the significance of the cueing effect was examined for different groups of participants according to established cut-offs on the LSAS. Note that for the following analyses only we deviate from our previous usage of social anxiety as dimension, and for the purposes of this analysis are considering scores in relation to possible diagnosis of Social Anxiety Disorder (although this measure in isolation cannot provide a definitive diagnosis). For participants scoring below the cut-off for probable social anxiety (LSAS < 60), the cueing effect was significant, $F(1, 55) = 18.31$, $p < .001$, $\eta_p^2 = .250$, $d = 1.15$, with faster RTs on valid (M = 646ms) compared with invalid trials (M = 676ms). For participants scoring in the probable social anxiety range (LSAS = 60-90), the cueing effect was not significant, $F(1, 34) = 4.07$, $p = .052$, $\eta_p^2 = .107$, $d = 0.69$. Participants scoring in the highly probable social anxiety range (LSAS > 90), also did not have a significant cueing effect, $F(1, 7) = 2.80$, $p = .138$, $\eta_p^2 = .286$, $d = 1.3$. This, therefore, indicates that participants with high levels of social anxiety were not able to orient to the cued happy faces when it was paired with the angry face.

Gender effect. Previous research has found some evidence of faster and more accurate detection of angry expressions for male faces and of happy expressions for female faces (Becker, Kenrick, Neuberg, Blackwell, & Smith, 2007), and that female observers have superior facial expression recognition (Hall, Hutton, & Morgan, 2010; Rahman, Wilson, & Abrahams, 2004). To test if face gender and participant gender impacted results, a 2 (face gender: female or male) x 2 (target expression: happy or angry) x 2 (distractor expression: neutral or emotional) x 2 (validity: valid or invalid) ANCOVA was conducted with the continuous predictor variable of social anxiety and the between-subjects factor of participant gender (female or male). No significant main or interactive effects were found for face gender (ps $\geq .132$) or participant gender (ps $\geq .157$).

Incorrect-cue trials. For incorrect-cue trials, the cue could either be “Happy” in the context of an angry-neutral face pair or it could be “Angry” in the context of a happy-neutral face pair. This provided an additional check that participants’ attention was not captured by the emotional face on happy-neutral and angry-neutral face pair trials, and instead that they were only orienting to the correctly cued facial expression. That is, quick responding to the probe replacing these un-cued emotional faces would indicate bottom-up attentional capture. Conversely, if responding was slower and on-par with the other invalid conditions, it would indicate that participants were able to ignore these emotional faces. To test this, data from valid happy-neutral and angry-neutral trials, which were previously used in the main analysis, were also used in this analysis. A 2 (target expression: happy or angry) x 2 (validity: valid or incorrect-cue) ANCOVA was conducted with the continuous predictor variable of social anxiety. This revealed a main effect of validity, as participants were significantly faster in the valid condition (M = 655ms) compared with the incorrect-cue condition (M = 670ms), $F(1, 97) = 19.77$, $p < .001$, $\eta_p^2 = .169$, $d = .90$).

A significant interaction was also found between social anxiety and target expression, $F(1, 97) = 5.26$, $p = .024$, $\eta_p^2 = .051$, $d = .46$). Next, two ANCOVAs with validity and social anxiety as factors were performed, one for when the angry face was the target, and one for when the happy face was the target. When the angry face was the target, there was a significant main effect of validity ($p = .001$), which did not interact with social anxiety ($p = .074$), and when the happy face was the target, there was a significant main effect of validity ($p = .001$), which did not interact with social anxiety ($p = .179$). That is, despite the significant three-way interaction, there was no evidence that the interaction between validity and social anxiety differed as a function of which face was the target, and so no further analyses were conducted or conclusions drawn[3]. In sum, data from the incorrect-cue-trials indicate that, on the happy-neutral and angry-neutral trials, participants' attention was not captured by emotion *per se* (i.e., regardless of the top-down goal) but, instead, oriented to the probe faster when its location matched their top-down goal.

Selection history effect. Finally, to test for effects of selection history, validity effects were compared between repeat and switch trials. On switch trials, participants had to shift their attention toward a different cued expression, as compared to the previous trial. By comparison, repeat trials were trials in which participants were cued to the same expression as on the previous trial. Trials were only included in these analyses if the previous trial was valid. The reason for this was that for valid trials, shifting toward the cued face was "rewarded" as the probe was presented in the locus of the cued face. Two additional participants' data were excluded as they had 0% accuracy in one of the conditions. Therefore, data from 97 participants were included in the following analyses.

To test the effect of selection history, a 2 (target expression: happy or angry) x 2 (validity: valid or invalid) x 2 (repetition: repeat or switch) ANCOVA was conducted with the continuous predictor variable of social anxiety. The analysis revealed a significant effect of repetition, $F(1, 95) = 4.48$, $p = .037$, $\eta_p^2 = .045$, $d = .43$, whereby participants were faster on repeat trials (M = 655ms) compared with switch trials (M = 672ms). All interactions with repetition were non-significant (ps ≥ .210), suggesting that, although repetition of the same target resulted in faster responding to the probe generally, it did not increase the validity effect. Therefore, selection history did not improve participants' ability to shift attention to the cued expression.

Discussion

The aim of the present study was to investigate the manner in which individuals who are relatively higher in social anxiety differ in their capacity to exert attentional control when presented with emotional stimuli, as compared to individuals relatively lower in social anxiety. It was found that individuals with high levels of social anxiety could attend to the cued facial expressions on most trials, suggesting that socially anxious individuals, at least in part, exert top-down attentional processes when orienting to emotional facial expressions. That is, individuals with social anxiety did not show a generic inability to use top-down attention. Instead, the deficit was more selective as individuals with high levels of social anxiety exhibited some deficits in top-down attention when orienting attention to happy expressions paired with angry faces. These results are discussed in more detail below.

Is Social Anxiety Associated with Deficits in Top-Down Attention?

The current study revealed that participants could orient their attention toward angry faces and were equally efficient at doing so irrespective of their level of social anxiety.

Similarly, participants could orient their attention toward happy faces when they were paired with neutral faces. Thus, it does not appear to be the case that individuals with social anxiety have a generically poorer ability to use top-down attention in all instances. However, higher levels of social anxiety were associated with a reduced ability to shift attention to a *happy face* when the non-target face was *angry*.

One of the conditions in this study (incorrect-cue condition) cued an expression that was not subsequently presented. For example, participants may have been instructed to attend to a happy face but were instead presented with an angry-neutral pair. RTs in this condition indicated that participants' attention was not captured by the surprising emotional face, which indicates that top-down attention can prevent attentional capture by an emotional face. This effect was found irrespective of participants' levels of social anxiety. Interestingly then, high levels of social anxiety were associated with difficulties orienting to happy faces paired with angry faces, but these participants did not appear to have difficulties inhibiting attention to irrelevant angry faces on angry-neutral trials.

These results are consistent with Attentional Control Theory (Eysenck et al., 2007), which hypothesises that, in the presence of threat-related stimuli, anxiety will be associated with greater impairments in task efficiency and/or performance when the task is demanding as this utilises greater attentional resources. In addition, previous research has emphasised the link between high social anxiety and deficits in attentional control (Moriya & Tanno, 2008; Wieser, Pauli, & Muhlberger, 2009). We suggest that trying to shift attention to a happy face while also suppressing bottom-up capture of attention to an angry face is a demanding task, which is why higher levels of social anxiety were associated with poorer top-down control. By contrast, simply having to inhibit attention to the angry faces in the incorrect-cue condition may be an easier task, which may be why no effects of social anxiety were found in this condition. These findings indicate that, for more complex stimuli, high levels of social anxiety are associated with deficits in orienting to positive stimuli in the presence of threatening stimuli. In everyday life, heavy demands are placed on the attentional system. For example, when giving a speech, people may need to read their notes, monitor the time, switch the slides in their slideshow presentation, and make eye-contact with the audience. These deficits in top-down control for socially anxious individuals may, therefore, be even more apparent in ecologically valid environments, such as in this situation.

It should be noted that we have interpreted spatial attentional cueing scores as reflecting top-down attentional control. This is because a non-zero cueing score implies that the participant complied with the instruction to attend to the cued facial expression, even when faced with other potentially more salient information in the display (as in the case where participants were instructed to attend to the happy face, but an angry face was displayed as the nontarget). It is standard practice in the attention literature to interpret attentional orienting of this nature as reflecting "attentional control settings" (see seminal paper by Folk et al., 1992), or more recently "top-down attentional control" (see review by Awh et al., 2012). Logically, therefore, when such cueing was diminished, we interpreted this as reflecting impoverished or impaired top-down attentional control. We believe that this is a legitimate interpretation that is well-grounded in prior empirical evidence and conceptual thought about such cognitive processes. Future research should consider inclusion of an independent measure of attentional control as provided, for example, by the Attentional Control Scale (ACS) (see Derryberry & Reed, 2002), or a state-based measure of a similar construct. Based on our interpretation of the experimental data, we predict that individuals who have lower self-reported attentional control would be more susceptible to interference in instantiating their top-down set, as revealed by diminished cueing scores.

Note that here we have emphasised the inadequacy of top-down attention to override capture by the non-task-relevant angry face amongst highly socially anxious individuals.

However, in doing so, we wish to be clear that in absence of an explicit measure of attentional control we can only speculate as to the nature of the attentional process that mediates this effect. Indeed, attentional orienting at any given moment reflects a combination of multiple factors, including top-down and bottom-up processes. To us, it seems likely that the bottom-up attentional salience of the angry faces may have been enhanced for individuals with high levels of social anxiety, and that this was in part what was driving reduced cueing scores when their task was to orient to the happy face instead of the angry face distractor. (However, it should be noted that bottom-up capture by the angry face was not revealed in other analyses – see performance on the Incorrect cue trials). What is striking, however, is that top-down attention could not override the (presumably) bottom-up attentional salience of the angry face and orient attention to the happy face as effectively as if the angry face were absent. In contrast, the basic attentional literature indicates that top-down attention can eliminate bottom-up attentional capture by stimuli with high levels of bottom-up attentional salience (e.g., onset flashes, colour singletons) (for a review, see Folk & Remington, 2010). Furthermore, the potency of top-down attention in determining orienting has even been shown with fear-relevant stimuli in an unselected sample (Vromen, Lipp, & Remington, 2015). *Therefore, the most important take-home message is that socially anxious individuals' top-down attention was not able to override the effects of the angry faces when they were not targets.* This demonstrates how using meaningful stimuli and considering relevant individual differences in susceptibility to these stimuli can reveal attentional effects that would not be evident across all individuals or all stimuli.

Specificity of stimulus effects: Future directions

It is worth acknowledging that while we unambiguously attribute the present results to a deficit in orienting to happy faces in the presence of a threatening (angry) distractor, it remains to be seen whether this effect generalises to other types of negative distractors or is specific to threat. Future research could test this possibility by including a sad target and distractor. In a similar vein, angry faces imply a *social* threat. It is conceivable that individuals with high levels of social anxiety are selectively sensitive to this type of threat, but not other types of threat (e.g., snakes and spiders). Further study in this area would provide further insight into the specificity of the top-down attentional deficit associated with social anxiety.

Comparing and contrasting with trait anxiety findings

In a similar vein to the current study, Basanovic and MacLeod (2017) employed a dot-probe task in which participants were given a top-down goal on each trial. This goal could be to either attend to or avoid real-world negative images. As with the current study, these researchers found that participants could use top-down attention to orient to the cued images. No differences in performance were found between participants with low and high trait anxiety, unlike the findings from the present study. However, there are a number of key differences between the current study and Basanovic and MacLeod's study that could account for why these researchers did not find deficits in performance for anxious participants. First, the current study utilised a 200ms image presentation time whereas Basanovic and MacLeod utilised a presentation time of 1000ms and, so, perhaps anxious participants only have deficits in initial, rapid orienting of attention but these deficits may no longer be observable at later stages of attention. Second, Basanovic and MacLeod investigated *trait* anxiety, whereas the current study investigated *social* anxiety. In addition to these being distinct psychological concepts, which in and of itself could reasonably be expected to lead to different patterns of results, this difference in the form of anxiety targeted led to a number of critical methodological differences in the designs of the two studies. That is, third, the current study found that anxious participants' deficits were selective to when happy and angry faces were directly paired together. Basanovic and MacLeod did not directly pair negative and positive images together as these images were instead always paired with an abstract image. Thus, in their study there was never the direct competition between positive and negative images which was the condition that differentiated between individuals with different levels of social anxiety here. Fourth, the stimuli used were different (facial expressions versus real-world scenes). Fifth, Basanovic and MacLeod's (2017) experimental procedure may have had low reliability, and in particular the use of reaction time difference scores may have undermined the ability to observe a relationship with the anxiety measure (for a discussion of experimental-task reliability for individual differences research, and the pros and cons of using difference scores, see Goodhew & Edwards, 2019). Further research will be required to systematically test which of these differences between the current study and Basanovic and MacLeod's (2017) study accounts for the contrasting findings.

Clinical Implications

Throughout this manuscript we have conceptualized social anxiety as a dimensional trait variable in the population, without necessarily invoking diagnostic criteria. However, high levels of self-reported trait social anxiety are likely to correlate with formal diagnoses, and even for those that do not, individuals may experience significant distress and can benefit from therapeutic approaches in the absence of a formal diagnosis. Here we discuss the clinical or therapeutic implications of the present work, and contextualize it in relation to previous research.

Since an attentional bias to threat is conceptualized as a maintaining factor for social anxiety, a growing body of research has attempted to develop therapeutic strategies and techniques to reduce this bias and, thus, reduce symptoms of social anxiety. This is known as attention bias modification (ABM; for a review, see Heeren, Mogoase, Philippot, & McNally, 2015). The most common method is a variant of the visual dot-probe task, in which probes nearly always (e.g., 95% of trials) follow non-threatening stimuli (e.g., neutral or happy faces). This task is designed to train individuals' attention away from threatening stimuli (e.g., angry or disgust faces) and, instead, toward neutral or positive stimuli. Although some studies have found that ABM results in reduced social anxiety (Amir et al., 2009; Amir, Weber, Beard, Bomyea, & Taylor, 2008; Heeren, Reese, McNally, & Philippot, 2012; Schmidt, Richey, Buckner, & Timpano, 2009), these results have not been replicated by other studies (Boettcher, Berger, & Renneberg, 2012; Boettcher et al., 2013; Carlbring et al., 2012; Julian, Beard, Schmidt, Powers, & Smits, 2012; McNally, Enock, Tsai, & Tousian, 2013). In fact, Boettcher et al. (2013) found that participants trained to attend to threat had the greatest improvements in social anxiety symptoms compared with the attend-positive and control condition, and Klumpp and Amir (2010) found that both attend-negative and attend-neutral conditions resulted in reductions in anxiety compared with a control condition. These mixed findings highlight the fact that the underlying mechanisms of this anxiety-related threat bias are not well understood.

The present research indicates that individuals possess an important resource which means that they are not always at the mercy of salient stimuli in the environment – namely top-down attentional control. However, it also revealed that individuals with high levels of social anxiety have a reduced ability to execute attentional control in the face of non-task-relevant threat. Targeting this deficit specifically may lead to improved therapeutic outcomes. The ability to regulate one's attention derives from working memory capacity (e.g., Bleckley, Durso, Crutchfield, Engle, & Khanna, 2003). This suggests that individuals with high levels of social anxiety may therefore benefit from training programs aimed at enhancing their working memory capacity, in particular in the context of non-task-relevant threat.

Does Selection History Impact the Threat Bias?

Selection history refers to the lingering effects of information from past trials (Awh et al., 2012). For example, if a participant responded to a red target on the previous trial, they may get captured again by a red object even if it no longer matches their top-down goal. Selection history was measured in the current study by comparing trials that repeated the same facial expression target (happy or angry) with those on which the facial expression target switched from the previous trial. This study found a general speeding effect for repeat trials compared with switch trials toward the probe. However, repetition did not interact with validity and, therefore, there was no evidence that repetition improved participants' ability to shift attention to the cued face relative to the distractor face. Furthermore, social anxiety did not interact with selection history effects.

The fact that selection history effects did not impact attentional orienting may appear at odds with the broader literature, but there are a number of reasons why selection history effects were not observed here. Of theoretical interest is the possibility that selection history effects may be weaker or absent for faces. This could be because a face is a more complex visual object than the simple geometric shapes used in previous research. Alternatively, it could be because facial expressions represent a *category* of object (e.g. happy faces) rather than a single individual exemplar (e.g., a particular happy face). Selection history effects may operate at the level of individual exemplars rather than object categories.

In contrast, selection history effects may occur for faces, but detection of such an effect may require a greater number of repetitions than used in the present study. While this is possible, multiple pieces of evidence speak against this as selection history effects have been observed for simple stimuli with the same number of repetitions present here (Belopolsky & Awh, 2016; Leonard & Egeth, 2008; Maljkovic & Nakayama, 1994; Mortier, Theeuwes, & Starreveld, 2005; Müller, Reimann, & Krummenacher., 2003; Theeuwes, Reimann, & Mortier, 2006; Theeuwes & Van der Burg, 2007; Zehetleitner, Krummenacher, Geyer, Hegenloh, & Müller, 2011). Altogether, the present results are promising in pointing to the imperviousness of more complex or category-level stimuli to the effects of selection history, but further research where selection history effects are compared for simple versus complex stimuli, and individual stimuli versus category-level groupings is required in order to answer this definitively.

Recently, Peschard and Philippot (2016) proposed that selection history may have an important role in attentional biases toward threat for social anxiety. That is, these authors speculated that since selection history is related to carry-over and lingering effects, it may contribute to patterns of rumination following social exposure which predispose individuals to social anxiety. Although we found no evidence for a relationship between self-reported social anxiety and repetition benefits, this does not necessarily mean that selection history does not play a part in social anxiety symptomatology. For instance, it is possible that the deficits observed for participants with high social anxiety may be overcome with selection history after further repetitions of the same target expression. Although this was beyond the scope of the current study, future research could conduct a trial-by-trial analysis to test the number of repetitions of the same cue that is required for socially anxious participants to be able to reliably shift attention toward happy faces in happy-angry face pairs.

Alternative Selection History Interpretation

Here, we tested if participants could follow a cued top-down goal of happy or angry faces and found a deficit in top-down control of attention. In doing so, an underlying assumption was that threat capture is due to bottom-up attention, which is consistent with an evolutionary perspective (Kenrick, Neuberg, Griskevicius, Becker, & Schaller, 2010; Lang, Bradley, & Cuthbert, 1997; LeDoux, 1996; LoBue, Rakison, & DeLoache, 2010; Mogg & Bradley, 1998; Öhman, 2007). However, another possibility is that participants with high levels of social anxiety may have had a chronic top-down attentional goal to attend to threat, which would have interfered with their cued top-down goal to attend to happy faces. Indeed, the role of top-down attentional beliefs is critical to Rapee and Heimberg’s (1997) cognitivebehavioural model of social anxiety. According to this model, individuals' top-down beliefs that they must make a good impression on others and that others are inherently critical will drive orienting of attention to threat. It is, therefore, possible that socially anxious participants had difficulty orienting to cued happy faces, not because their attention was automatically driven to attend to threat, but because they had a top-down goal of attending to threat, which is chronically activated in social situations. Further research is needed to test these proposals. However, even if this is the correct interpretation, our overarching conclusion would still hold – socially anxious participants have a poorer ability to regulate their top-down control in the presence of threat.

Spatial versus Temporal Attention

The present study focussed on the mechanisms of *spatial* attention, that is, how and where attention is allocated across space. However, another important attentional process is *temporal* attention, that determines which stimuli are selected in time. A useful laboratory tool for examining the role of emotion in temporal attention is that of *emotion-induced blindness* (EIB). Here, a rapid serial visual presentation (RSVP) stream of images is presented, and participants' task is to identify the orientation of a neutral landscape image (rotated 90° to the left/right of vertical). Prior to the target, a critical distractor is presented which is either neutral or emotionally-evocative. Emotionally-evocative stimuli, both highly pleasant (i.e., erotica) and unpleasant images (e.g., mutilated bodies, scenes of attack) automatically capture attention even though they are not task-relevant, and impair participants' ability to perceive the target when it follows the critical distractor close in time (Most et al., 2005, 2007). While this effect is heightened in those with high levels of self-reported negative affect (Onie & Most, 2017), it also robustly occurs in the general population. Recent work shows that negative (angry) faces can produce emotion-induced blindness, even in non-anxious participants (Gutiérrez-Cobo et al., 2019). This contrasts with spatial-attentional phenomena which appear to be more selective to individuals high in anxiety (e.g., meta-analysis by Bar-Haim et al., 2007). Furthermore, it has been shown that spatial-attentional versus temporal-attentional threat-effects predict unique variance in negative affect (Onie & Most, 2017). Altogether, this suggests that it is important to consider how threatening stimuli influence the dynamics of spatial and temporal attention separately. In particular, it will be interesting for future work to determine if, for example, individuals high in social anxiety are more susceptible to emotion-induced blindness with angry faces.

Conclusion

In conclusion, in the typical dot-probe task, participants are not instructed to attend to any of the displayed facial expressions and, instead, the task measures naturally occurring biases in attention. Using this paradigm, most research indicates that socially anxious individuals have a bias toward threatening faces relative to neutral faces (Mogg et al., 2004; Pishyar et al., 2004). In the current study, participants were directly cued to happy and angry facial expressions to explicitly test the role of top-down attention in the process of attending to emotional faces. Building on the theoretical and clinical research of Bishop et al. (2007) and Eysenck et al. (2007), the current findings suggest that socially anxious individuals did not have a general top-down deficit but instead had selective difficulty orienting toward happy faces when paired with distracting threatening stimuli. The next avenue for research is to understand how this deficit in top-down attentional control can be overcome to further aid treatments of social anxiety.

Notes

1. Note that the AccOverall and RTOverall variables in the raw data files were computed from all correct trials for RT and all trials for overall accuracy (on which a valid keypress was made).
2. Partial-eta squared values were converted to Cohen's d values using the transformation of effect sizes calculator (partial-eta-squared to Cohen's d) provided by https://www.psychometrica.de/effect_size.html#transform.
3. Note that we are maintaining a consistent criterion for whether an effect or interaction is considered statistically significant (i.e., $p < .05$). This interaction was deemed to be non-substantive because subsequent follow-up tests of the interaction yielded non-significant (i.e., $p > .05$) results in relation to the social anxiety variable.

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