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Attentional biases in social anxiety: An investigation using the inattentional blindness paradigm

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A B S T R A C T

One line of research has examined attentional bias as a potential maintenance factor in social anxiety using cognitive experiment paradigms. The present study sought to examine the utility of the *inattentional blindness* (*IB*) *paradigm* for assessing attentional bias in social anxiety. Unlike other existing paradigms such as the emotional Stroop or dot-probe tasks, the IB paradigm has the advantage of eliminating the individual's expectation and intention to search for social cues, which would reduce strategic or effortful responses. Two independent experiments were conducted using college students scoring high or low on the Fear of Negative Evaluation Scale. In both Experiments 1 and 2, participants were randomized to one of three IB experiment conditions, in which a positive face, a negative face, or a neutral item was unexpectedly presented, in the presence/absence of a bogus-speech threat. The overall pattern of our data suggests the presence of hypervigilant attentional processing in social anxiety. The IB paradigm appears to be a useful addition to existing experiment paradigms for investigating attentional bias in social anxiety and perhaps other psychopathology.

Introduction

Over the past two decades, there has been a dramatic increase in clinical research aimed at examining underlying mechanisms of social anxiety. One line of research has utilized research paradigms borrowed from cognitive psychology (e.g., Stroop Task) to assess biased information processing associated with social anxiety. Particularly, attentional biases (e.g., self-focused attention, biased attentional processing of external social cues) have been placed at the core of current cognitive–behavioral models of social anxiety (Clark, 2001; Clark & Wells, 1995; Rapee & Heimberg, 1997).

Research on biased attentional processing in social anxiety

Investigations of biased attention in social anxiety have varied along several dimensions including: (a) the paradigm used for assessing attentional bias (e.g., emotional Stroop task vs. dot-probe paradigm); (b) the nature of socially threatening cues (e.g., words vs. faces); (c) subjects' clinical status (i.e., meeting threshold diagnoses for SAD vs. displaying non-clinical social anxiety); and (d) inclusion of a social anxiety induction manipulation prior to the assessment of attentional biases.

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The Emotional Stroop and the Dot-Probe tasks have been the most frequently used assessment paradigms for studying biased attention in social anxiety. As reviewed by Bögels and Mansell (2004), most studies using the Stroop paradigm have shown that individuals with heightened social anxiety or SAD display longer color-naming latencies in response to social threat words (e.g., Amir, Freshman, & Foa, 2002; Andersson, Westoo, & Johansson, 2006; Becker, Rinck, Margraf, & Roth, 2001; Hope, Rapee, Heimberg, & Dombeck, 1990; Lundh & Ost, 1996; Maidenberg, Chen, Craske, Bohn, & Bystritsky, 1996; Mattia, Heimberg, & Hope, 1993; McNeil et al., 1995; Spector, Pecknold, & Libman, 2003) with very few exceptions that have revealed no or shorter response latencies (e.g., Amir et al., 1996; Kindt, Bögels, & Morren, 2003). Despite the overall success of the emotional Stroop paradigm in demonstrating longer color-naming latencies linked to social anxiety, some methodological and interpretational problems weaken its status as an attentional bias measure for social anxiety. First, several authors have indicated that the Stroop effect is likely confounded with various non-attentional mental processes such as mental preoccupation, cognitive avoidance, or emotional reaction to threat words (Asmundson & Stein, 1994; Bögels & Mansell, 2004; Heinrichs & Hofmann, 2001; Williams, Mathews, & MacLeod, 1996). Second, it has been shown that the Stroop interference effect can be overridden by effortful control strategies (Amir et al., 1996, 2002). In sum, the emotional Stroop paradigm may tap other cognitive processes in addition to attentional biases.

The modified dot-probe paradigm has also been used extensively in social anxiety research. Bögels and Mansell (2004) have outlined several methodological advantages of the dot-probe paradigm over the Stroop. These include: (a) true selective attention can be examined via the simultaneous presentation of threat and distracter items, (b) the reliance on a meaningless detection cue (i.e., a dot) reduces the threat that reaction times are affected by mental preoccupation, and (c) both hypervigilance and avoidance can be indexed in the same paradigm. Studies using this paradigm in social anxiety have yielded mixed findings, suggesting hypervigilance (e.g., Amir, Elias, Klumpp, & Przeworski, 2003; Mogg & Bradley, 2002; Mogg, Philippot, & Bradley, 2004; Musa, Lepine, Clark, Mansell, & Ehlers, 2003; Sposari & Rapee, 2007), attentional avoidance (e.g., Chen, Ehlers, Clark, & Mansell, 2002; Mansell, Clark, Ehlers, & Chen, 1999), or no evidence of attentional bias to social threat cues (e.g., Horenstein & Segui, 1997; Mansell, Ehlers, Clark, & Chen, 2002).

The dot-probe paradigm also has potential methodological limitations. First, several dot-probe studies using threat word stimuli demonstrated attentional biases only when threat cues appeared in the upper area of the screen, to which initial visual attention may be oriented (Asmundson & Stein, 1994; Horenstein & Segui, 1997). These findings may suggest that the relative cue detection speed indexed by the dot-probe paradigm could reflect the influence of individuals' visual response pattern in addition to attentional competition between the paired items. Relatedly, Mogg et al. (2000) suggested that high trait anxious individuals may easily use *strategies* to counteract their vigilance towards threat words and that the dot-probe paradigm presents a relatively fragile index of attentional biases in normal samples. Second, this paradigm places social cues in competition with non-social or less threatening social cues in order to index attentional bias. This comparative context allows one to examine the relative attentional attraction/repulsion of socially threatening cues in comparison with other adjacent stimuli, but precludes the independent assessment of the attentional processing of the social cue itself. It remains unclear how the social cue itself was processed. The competition within the pair of stimuli may also pose some interpretative ambiguity with respect to underlying response mechanisms. For instance, the faster detection of a dot following a more threatening cue, relative to a less threatening or neutral cue, may arise from the inhibition of the less threatening cue, the facilitation of the more threatening cue, or both (see Cooper & Langton, 2006; Koster, Crombez, Verschuere, & De Houwer, 2004). Unlike previous studies, Cooper and Langton (2006) revealed that it was not the vigilance to the threat, but the inhibition of less threatening cues that accounted for the faster detection of the probe following threatening faces.

Static inattentional blindness paradigm

An intriguing perceptual phenomenon called inattentional blindness (IB) has been the focus of study by cognitive psychologists. In the typical IB experiment, subjects fail to notice a supra-threshold stimulus unexpectedly presented in front of their eyes while engaging in a perceptual discrimination task. Mack and Rock (1998) developed a static IB task, in which the subject is presented a cross on the screen for 200 ms followed by a circular pattern mask lasting for 500 ms. Subjects are first presented several regular discrimination trials in which they have to choose which of the two lines of the cross (horizontal vs. vertical) is longer. However, on the third or fourth trial, an extra object (i.e., critical item) unexpectedly appears for 200 ms *at fixation* along with the target cross (i.e., the *inattentional* trial). Following this critical trial, subjects are then asked whether they saw anything appear on the screen other than the target discrimination cross. Testing a number of simple geometric figures (e.g., a black or colored small square) as critical items during the IB trial, Mack and Rock (1998) found that approximately 75% of the subjects *failed* to detect the critical stimulus presented in the fovea. Interestingly, they discovered that certain stimuli had significantly higher rates of detection or conversely, markedly lower IB rates (80% detection rate = 20% IB rate). More specifically, a smiling face icon was detected and identified better than a frowning face or a circle of the same size (detection rates—smiling face = 85%, frowning face = 40%, circle = 15%; identification rates among the detectors—smiling face = 88%, frowning face = 63%, circle = 15%). Via a number of follow-up experiments, Mack and Rock (1998) put forth *the meaningfulness–signal hypothesis* asserting that these exceptional objects are more easily noticed under the inattentional condition due to their *meaningfulness*. When these stimuli were slightly transformed to obliterate their meaning while maintaining the global sensory features (e.g., changed "Jack" to

"Jeck", turned the smiling face upside down), their unique capability to capture attention in the inattentional trial was significantly attenuated (Mack & Rock, 1998). Moreover, the authors repeatedly showed that the physical salience of the critical item had minimal influence on whether it was detected relative to the meaningfulness of the critical stimulus (Mack & Rock, 1998).

Sustained inattentional blindness paradigm

An alternative IB task using a more sustained stimulus presentation was developed by Most and colleagues (Most, Scholl, Clifford, & Simons, 2005; Most et al., 2001). In this sustained IB task, for example, two white squares, two white circles, two black squares, and two black circles appear on the computer display moving in haphazard paths occasionally bouncing off the edges of the display. The subject's task during this 15 s trial is to count the number of times a particular type of object (e.g., shape—all circles/color—all black objects) bounces off the edges of the display. This constitutes a regular judgment trial. On the third inattentional trial, an unexpected object enters the middle of the right side of the display and slowly moves and exits to the left side of the display over a period of 5 s.

Most and colleagues have demonstrated that the sustained IB task can effectively generate IB and that this is strongly influenced by the viewer's *attentional set* (Most et al., 2005, 2001). For example, in one experiment using the above-mentioned eight distracters with a *black circle* as the critical item, most subjects who were instructed to attend to either the black shapes or the circles detected the critical item (88% and 81%, respectively). In contrast, almost none of those who were instructed to attend to either the white shapes or the squares detected the black circle (0% and 6%, respectively). Another experiment using the same set of distracters with a *gray circle* as the critical item again revealed the predominant role of attentional set despite the increased salience of the critical item. Of those instructed to attend to the circles, 86% detected the gray circle; whereas those instructed to attend to the squares, only 7% detected it (Most et al., 2005). Overall, these data support the central role of the viewer's mindset to attend to certain properties of the critical item in detecting its unexpected emergence in the sustained IB task.

The IB paradigm has several potential methodological strengths for assessing attentional biases associated with psychopathology in general and social anxiety in particular. The unexpected presentation of the critical stimulus in the IB paradigm reduces the chance that individuals will engage in effortful or strategic reactions during the attentional task. Moreover, the IB paradigm may provide a more direct measure of hypervigilance to the social threat cue itself, relative to the emotional Stroop or dot-probe paradigms in which attentional biases are inferred indirectly through either slower (Stroop) or faster (dot-probe) processing of non-social stimuli (i.e., color of words or location of dots).

Aims of the present study

The principal goal of the present study was to examine the utility of the IB paradigm for investigating attentional bias in social anxiety. To this end, two independent experiments were conducted using the IB paradigm. We employed an analog approach, which makes it possible to pilot a new experimental task in an efficient fashion and to use a complex experimental design requiring a large number of subjects (Stopa & Clark, 2001). In both Experiments 1 and 2, college students who displayed high levels of social anxiety (HSAs) or those who displayed low levels of social anxiety (LSAs) as indexed by the Fear of Negative Evaluation Scale (FNES; Watson & Friend, 1969) were randomly assigned to one of three critical item conditions (i.e., positive face, negative face, or neutral item) in the presence or absence of a bogus-speech threat manipulation.

Experiment 1

Given the first attempt to apply the static IB task to a psychopathology context, we sought to replicate the original experimental parameters of the Mack and Rock (1998) study that had used the schematic facial icons (i.e., smiling face, frowning face, and circle) as critical items. In the context of social anxiety, negative facial expressions are likely to carry a more meaningful signal portending negative social evaluation for HSAs relative to LSAs. Thus, we hypothesized that in the inattentional trial, HSAs would be more likely to detect/identify the frowning face relative to LSAs; LSAs would be more likely to detect/identify the smiling face relative to HSAs; and that these hypothesized differences in detection/identification rates would be present *only* for participants assigned to the bogus-speech condition. We presumed that the anticipation of a social-evaluative event would maximize the underlying cognitive differences between HSAs and LSAs in response to social cues. Thus, we predicted a three-way interaction between social anxiety status (high vs. low), bogus-speech manipulation (present vs. absent), and critical item condition (smiling face vs. frowning face).

Method

Participants

Undergraduate students ($N = 1684$) enrolled in introductory psychology courses at a large southwestern university were screened using the FNES. Those who scored less than or equal to 10 (LSAs; $N = 410$) or greater than or equal to 22

(HSAs; $N = 421$) were invited to participate in the experiment in partial fulfillment of their experimental credit. Of those, 298 students replied to the invitation. Upon retesting, 22 participants no longer met the FNES criteria. The final sample consisted of 276 students (110 males, 166 females, mean age = 18.95 years, SD = 1.51). They were ethnically diverse: Caucasian (54.2%), Hispanic (21.5%), Asian/Pacific Islander (15.3%), African American (5.8%) and other (3.2%).

Materials

An IB task was generated following the description of the original study (Mack & Rock, 1998). All trials took place on a white background of a 14.1 inch color monitor screen, from which the subject was seated at a 76 cm distance. Each regular discrimination trial proceeded as follows: (a) a tiny black central cue was presented on the white screen for 1500 ms; (b) a target cross appeared in the parafovea within 2.3° of fixation on one of the four quadrants for 200 ms; (c) the cross was replaced by a circle 10.6 cm in diameter with a complex black and white pattern lasting for 500 ms; and (d) subjects were then asked to indicate their judgment as to the relative length of the cross lines by pressing the "V" key in the case of the vertical line being longer, or the "H" key in the case of the horizontal line being longer. The experiment consisted of 10 discrimination trials in total. The size of the target cross varied from trial to trial, with the length of a cross line ranging from 3.0° to 4.5°. The difference between the vertical and horizontal lines was approximately .3–.5°.

Of the 10 trials, the fourth, eighth, and tenth trials presented an additional unexpected item *at fixation* along with the target cross in the parafovea for 200 ms with all other steps of the trials being equal. The fourth trial constituted *the inattentional trial*. During this trial, participants were presented with a smiling face, frowning face, or circle. The smiling and frowning faces differed only with respect to the orientation of the mouth: a U-shaped versus an inverted U-shaped mouth. The circle was of the same size with the two facial icons. These critical items subtended a visual angle of .6° (i.e., approximately 1 cm). In this trial, after the regular cross judgment procedure, the subjects were asked whether they saw anything that had not been present on the screen. Affirmative responses were further probed by the experimenter (i.e., what kind of object did you notice? How big was the object? Where did you see that?). These probes were designed to rule out false-positive detection response by ensuring that the participants were referring to the intended target object when they reported having seen an additional object. Thus, participants' responses to this probing were not used in the data analyses. Then, a recognition test followed asking them to select what they saw in the inattentional trial from an array of five items consisting of a square, a diamond, and the three critical items (see Fig. 1). If they reported seeing nothing but the cross, they were first asked to guess what they failed to detect. Following this open-ended probe, they were then presented the object array and instructed to select the stimulus that they failed to detect.

The eighth trial was identical to the fourth trial, but constituted a *divided attentional* trial because the subject was likely to be privy to the possible emergence of an extra object. The tenth trial presented the same critical item used in the fourth and eighth trials. Prior to the start of this trial, subjects were instructed to ignore the cross and just to report what they may see in the display, thereby constituting the *full attentional trial*.

Experimental design

A 2 × 3 × 2 completely crossed factorial design was used to investigate the singular and interactive effects of the three between-group factors (i.e., social anxiety status, critical item condition, and bogus speech manipulation) on detection/identification rates. HSAs and LSAs were each randomized to one of six experimental conditions: (a) frowning face—bogus speech, (b) frowning face—no bogus speech; (c) smiling face—bogus speech, (d) smiling face—no bogus speech; (e) circle—bogus speech, (f) circle—no bogus speech. Participants' detection/identification of the critical item was assessed under three separate critical trials: Trial 4 (inattention trial), Trial 8 (divided attention trial), and Trial 10 (full attention trial).

Measures

The FNES is a 30-item questionnaire measuring social-evaluative concern. Its pre-screening criteria were derived from a pilot study based on 1520 students at a large southwestern university that revealed total scores of "22 or higher" and "10 or lower" on the FNES corresponding to cutoff scores for the top and bottom 25%, respectively. The FNES has been extensively used in analog studies of SAD, and its validity in this context has been well demonstrated (for a review, see Stopa & Clark, 2001). It distinguishes those with social phobia from normal controls and patients with other anxiety disorders. Moreover, the differences observed between high and low scorers on the FNES mirror those observed between those with social phobia and non-anxious controls.

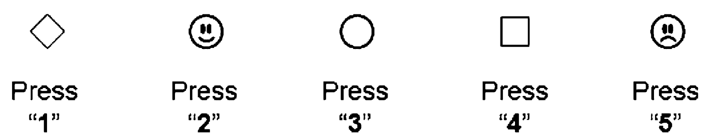

Fig. 1. Object array for the recognition test in Experiment 1.

A battery of social anxiety measures was administered prior to the IB task, which included: (a) the FNES; (b) Social Interaction Anxiety Scale (SIAS: Mattick & Clarke, 1998)—a 19-item questionnaire assessing social anxiety experienced in dyadic and group interactions; and (c) Social Phobia Scale (SPS: Mattick & Clarke, 1998)—a 20-item questionnaire assessing fear of performance and observation situations. General emotional distress was measured by the State Trait Anxiety Questionnaire-Trait Version (STAI-T; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1970) and the Beck Depression Inventory (BDI; Beck, Ward, Mendelsohn, Mock, & Erlbaugh, 1961). An author-constructed[1] mood checklist was administered to obtain participants' ratings on eight emotional adjectives (i.e., angry, anxious, happy, despondent, tense, rested, nervous, and jittery) in reference to their current mood on a 0 (Not at all) to 100 (Extremely) scale. Of these, five anxiety-related adjectives (i.e., anxious, tense, rested, nervous, and jittery) were used to generate the manipulation check for the bogus speech manipulation.

Procedure

The experimenter met with each participant in the laboratory and provided an explanation about the study. Participants were told that the study was designed to examine the nature of social discomfort and that the procedure would involve a packet of questionnaires, a short computer task, (and a videotaped speech task in the case of subjects who were assigned to the bogus speech condition). After obtaining informed written consent, the questionnaire battery was administered. Upon its completion, those assigned to the social anxiety induction condition received an additional instruction, "We will ask you to prepare and give a 3-min videotaped speech in front of a panel of three speech evaluators. They will evaluate your speech in terms of appearance, speech content, vocalization, interaction with the audience, and demonstrated confidence. I will provide you with a list of speech topics from which you can choose to speak about, and you will be left alone for 3 min to prepare the speech". The subject was then given a list of 12 controversial speech topics (e.g., abortion, seatbelt regulation laws, gay marriage, war in Iraq, etc.) and spent 3 min preparing for the speech on the selected topic. After the 3 min, the experimenter came back with a video camera and said "The preparation time is over. This video camera will be used to record your speech. Now before starting the speech task, you need to carry out a computer task as part of the pre-assessment". The mood checklist was administered again before the IB computer task began. In contrast, participants who did not undergo the bogus-speech manipulation were given instead a 3-min break after completing the questionnaire battery.

After the experimenter explained about the cross-line discrimination task, the subject began the IB computer task by pressing the space bar of the keyboard. According to the assigned condition, one of three IB tasks was executed presenting a smiling face, a frowning face, or a circle as the critical item. Throughout the IB task, the experimenter stayed at a distance of 1.5 m from the subject and remained silent except in the three critical trials, in which they guided the subject through each additional probing step.

Data analysis

Two primary indices were derived from critical trials: (a) the proportion of those who *detected* the critical item (detection rate) and (b) the proportion of those who *detected and identified* the critical item (identification rate). Hierarchical logistic regression analyses were performed to examine the singular and interactive effects of the three independent variables (i.e., social anxiety status, critical item condition, and social anxiety-induction manipulation) on the binary outcomes of detection and identification in the inattentional trial.

Statistical power to detect differences in detection and identification rates. The program G^* Power 3 (SPSS, Release 2.0) was used to calculate power for the analyses examining differences in detection/identification rates. Power analyses were conducted for the most stringent analytic test—the social anxiety status $\times$ critical item $\times$ bogus speech manipulation three-way interaction—following the logic that if we have sufficient power for these stringent analyses, we will have more than adequate power for the less stringent analyses. Our power to detect a medium effect size (difference in detection/identification rate of .25) in the hypothesized direction with the sample size in Experiment 1 and setting α at .05 (one-tailed) was .79.

Results

Group characteristics

Table 1 presents means and standard deviations of the demographic and clinical measures across the 12 experimental conditions. Compared with LSAs, HSAs consisted of more females (67% vs. 54%), $\chi^2(1) = 4.70$, $p = .030$. HSAs also scored significantly higher than LSAs on the FNES (mean = 25.22 vs. 5.54), $t(274) = 59.93$, $p < .001$; SPS (mean = 28.55 vs. 7.09), $t(274) = 17.44$, $p < .001$; SIAS (mean = 36.21 vs. 12.97), $t(274) = 20.02$; $p < .001$; BDI (mean = 11.73 vs. 3.60), $t(274) = 11.51$,

[1] We constructed a shorter and more anxiety-focused mood checklist consisting of five anxiety-related adjectives and three filler items, compared with the existing ones such as the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Carey, 1988—20 items), the Mood Adjective Check List (MACL; Nowlis, 1965—36 items), and the Profile of Mood States (POMS; McNair, Lorr, & Droppleman, 1971—65 items). This aimed to minimize the possible interference effect of its repeated administration on the computer task.

Table 1
Demographic variables, clinical measures, and pre- and post manipulation state anxiety scores across 12 groups in Experiment 1

	No speech						Bogus speech					
	Smiling		Frowning		Circle		Smiling		Frowning		Circle	
	LSAs ($N=25$) M (SD)	HSAs ($N=24$) M (SD)	LSAs ($N=24$) M (SD)	HSAs ($N=23$) M (SD)	LSAs ($N=22$) M (SD)	HSAs ($N=20$) M (SD)	LSAs ($N=25$) M (SD)	HSAs ($N=25$) M (SD)	LSAs ($N=23$) M (SD)	HSAs ($N=21$) M (SD)	LSAs ($N=22$) M (SD)	HSAs (N = 22) M (SD)
Age	19.48 (2.60)	18.96 (.75)	18.75 (.44)	18.83 (1.07)	19.50 (1.82)	18.50 (.61)	18.80 (1.12)	18.76 (1.64)	18.87 (1.06)	18.62 (.92)	19.05 (1.76)	19.18 (2.40)
Gender (% male)	40	29	42	43	36	35	48	32	56	33	55	2
FNES	4.92 (3.34)	25.21 (2.36)	5.88 (2.63)	24.96 (2.67)	6.09 (3.39)	24.30 (3.01)	5.48 (3.07)	25.20 (2.00)	4.57 (2.79)	25.81 (2.16)	6.41 (2.75)	25.82 (2.13)
SPS	6.16 (3.54)	28.79 (14.90)	7.63 (4.50)	27.30 (11.57)	8.36 (7.42)	23.70 (11.59)	6.88 (4.19)	30.28 (14.65)	6.65 (8.24)	31.57 (11.44)	6.95 (4.23)	29.14 (15.69)
SIAS	11.24 (4.00)	32.08 (12.40)	14.50 (4.77)	36.26 (12.21)	13.82 (6.73)	31.20 (9.87)	12.24 (5.90)	40.04 (11.92)	12.04 (5.83)	37.19 (12.27)	14.23 (6.24)	39.91 (13.04)
BDI	2.16 (2.59)	12.17 (8.30)	3.33 (2.81)	13.57 (9.41)	4.91 (3.89)	7.80 (5.52)	3.28 (3.06)	11.92 (6.48)	4.26 (3.62)	11.29 (6.92)	3.91 (4.37)	13.09 (6.75)
STAI	31.68 (4.77)	49.42 (9.38)	31.83 (7.60)	50.13 (7.36)	34.32 (7.44)	45.65 (8.12)	31.16 (9.37)	53.80 (8.80)	31.43 (8.31)	49.86 (10.46)	37.27 (12.92)	51.77 (10.56)
Pre-anxiety	15.28 (5.97)	30.92 (16.12)	17.67 (8.72)	32.09 (16.52)	17.36 (10.94)	29.40 (14.39)	18.64 (12.37)	38.64 (16.08)	17.04 (16.66)	39.86 (18.44)	13.64 (8.96)	35.73 (19.13)
Post-anxiety	14.16 (6.61)	30.42 (17.39)	17.83 (8.52)	33.39 (16.03)	16.36 (14.46)	29.40 (13.75)	29.88 (17.56)	73.52 (14.37)	28.87 (19.00)	71.14 (17.68)	27.00 (19.54)	61.55 (24.18)

$p<.001$; and STAI-trait (mean = 50.24 vs. 32.86), $t(274)=15.94$, $p<.001$. There were no significant differences in the demographic and clinical measures between the two bogus-speech conditions or the three critical item conditions.

Bogus-speech manipulation check

The effectiveness of the bogus-speech threat manipulation was assessed by comparing the pre- and post-manipulation anxiety index computed from the Mood Checklist for participants in the two bogus-speech threat conditions. The two groups did not differ significantly in their pre-manipulation state anxiety scores (bogus-speech condition—mean = 27.15, SD = 18.84; no bogus-speech condition—mean = 23.59, SD = 14.32; $t(274)=1.77$, $p=.079$). Whereas, after the bogus-speech manipulation, those who received the manipulation reported significantly higher anxiety scores (mean = 48.49, SD = 27.65) compared with those who did not receive the manipulation (mean = 23.39, SD = 15.16), $t\ (274)=9.35$, $p<.001$. The differences between pre- and post-manipulation anxiety scores were also significant only for those who received the bogus-speech manipulation, $t(137)=12.84$, $p<.001$. Table 1 presents the means and standard deviations of pre- and post-manipulation anxiety scores across the 12 experimental groups. Overall, relative to LSAs, HSAs displayed a greater increase in the anxiety scores in response to the bogus-speech threat. These data suggest that the bogus speech task was successful in producing a significant increase in state anxiety.

Differences in detection rates for the inattentional trial

In order to predict the binary outcome of detection performance from the inattentional trial, a hierarchical logistic regression model was examined with the three main effects (i.e., social anxiety status, critical item condition, and bogus-speech manipulation) entered in Step 1, the three two-way interaction terms formed by the cross-product of the three predictors in Step 2, and the three-way interaction term in Step 3.

Table 2 presents the detection rates across the 12 experimental groups. In Step 1, there was a main effect only for the critical item condition: (a) the smiling face was detected better than the circle (60.6% vs. 24.4%), $B=1.56$, Wald = 23.15, $p<.001$, odds ratio = 4.77, 95% confidence interval (CI) [2.52, 9.01]; and (b) the frowning was also detected better than the

Table 2
Detection and identification rates of the three critical trials across the 12 Experiment groups in Experiment 1

	No speech						Bogus speech					
	Smiling		Frowning		Circle		Smiling		Frowning		Circle	
	LSAs	HSAs	LSAs	HSAs	LSAs	HSAs	LSAs	HSAs	LSAs	HSAs	LSAs	HSAs
Inattentional												
Detection rate (%)	68.0	66.7	50.0	65.2	22.7	20.0	60.0	48.0	69.6	76.2	27.3	27.3
Identification rate (%)	56.0	66.7	37.5	43.5	9.1	15.0	60.0	40.0	26.1	61.9	22.7	22.7
Divided attention												
Detection rate (%)	92.0	100.0	83.3	100.0	90.9	78.9	96.0	96.0	91.3	90.5	72.7	68.2
Identification rate (%)	88.0	83.3	58.3	87.0	81.8	75.0	84.0	92.0	73.9	76.2	72.7	68.2
Full attention												
Detection rate (%)	100.0	95.8	100.0	100.0	95.5	100.0	100.0	100.0	95.7	100.0	100.0	95.5
Identification rate (%)	92.0	87.5	87.5	95.7	90.9	100.0	96.0	96.0	87.0	100.0	95.5	95.5
Overall accuracy– cross discrimination (%)	72.4	65.3	76.4	78.7	71.7	79.5	79.6	66.7	73.9	76.2	70.7	70.7

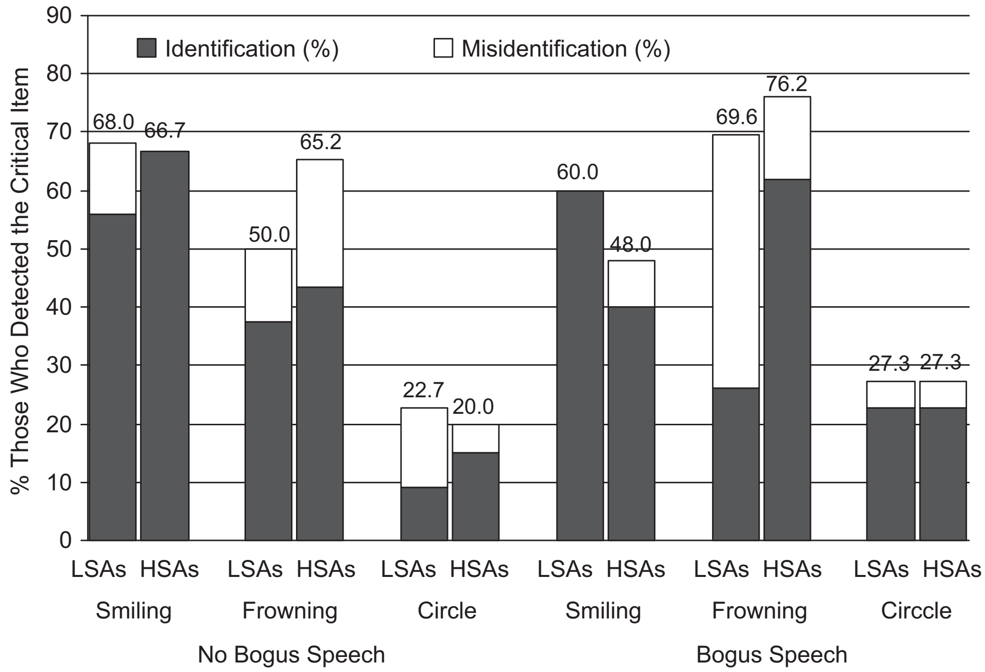

Fig. 2. Detection rates from the inattentional trial in Experiment 1.

circle (64.8% vs. 24.4%), $B = 1.75$, Wald = 27.35, $p < .001$, odds ratio = 5.73, 95% CI [2.98, 11.02]. In Step 2, a significant two-way interaction was observed between the critical item and the bogus-speech manipulation conditions ($B = 1.25$, Wald = 4.09, $p = .043$, odds ratio = 3.48, 95% CI[1.04, 11.63]). Follow-up analyses showed that participants under the bogus speech threat were significantly more likely to detect the frowning face better than the smiling face (72.7% vs. 54.0%), Fisher's Exact Test, $p = .048$. In contrast, there was a non-significant reverse trend among those who did not receive the bogus speech threat to detect the smiling face better than the frowning face (67.3% vs. 57.4%), Fisher's Exact Test, $p = .215$. Fig. 2 depicts this significant critical item by bogus-speech threat interaction. However, in Step 3, the three-way interaction was not significant.

Differences in identification rates for the inattentional trial

The same analytic procedure was applied to the binary outcome of identification from the inattentional trial. Step 1 revealed a significant main effect for the critical item condition indicating: (a) the smiling face was identified better than the circle (55.6% vs. 17.4%), $B = 1.78$, Wald = 26.02, $p < .001$, odds ratio = 5.95, 95% CI [3.00, 11.81], and (b) the frowning face was also identified better than the circle (41.8% vs. 17.4%), $B = 1.23$, Wald = 11.92, $p = .001$, odds ratio = 3.42, 95% CI [1.70, 6.86]. In Step 2, none of the two-way interaction terms were significant. In Step 3, the three-way interaction term involving the contrast between the smiling and frowning faces was significant above and beyond the main effects of the three individual predictors and their two-way interactions, $B = 2.54$, Wald $= 4.41$, $p = .036$, odds ratio $= 12.70$, 95% CI [1.18, 136.17]. To further probe this three-way interaction, the two-way critical item by social anxiety status interaction was further examined for each level of the bogus-speech manipulation. Results revealed a significant critical item (smiling vs. frowning face) by social anxiety status interaction only for those who received the bogus-speech threat, $B = 2.34$, Wald $= 7.19$, $p = .007$, odds ratio $= 10.36$, 95% CI [1.88, 57.25]. Further analyses revealed that under the bogus-speech threat, HSAs outperformed LSAs in identifying the frowning face (61.9% vs. 26.1%), Fisher's exact test, $p = .018$. In contrast, there was a non-significant reverse trend for LSAs to outperform HSAs in identifying the smiling face (60.0% vs. 40.0%), Fisher's exact test, $p = .129$. In the absence of the bogus-speech threat, HSAs and LSAs did not differ in identifying the facial icons.

The observed three-way interaction was also inspected by comparing the smiling vs. frowning face conditions separately for LSAs and HSAs. LSAs who received the bogus-speech threat identified the smiling face significantly better than the frowning face (60.0% vs. 26.1%), Fisher's exact test, $p = .018$. There was a non-significant reverse trend for HSAs to identify the frowning face better than the smiling face (61.9% vs. 40.0%), Fisher's exact test, $p = .118$. In contrast, both LSAs and HSAs assigned to the no bogus-speech condition, showed a non-significant trend towards a better identification of the smiling face over the frowning face (LSAs—56.0% vs. 37.5%, Fisher's exact test, $p = .156$; HSAs—66.7% vs. 43.5%, Fisher's exact test, $p = .096$).[2]

Additional evidence of vigilant attention towards the critical item

Finally, we conducted additional analyses to further examine the evidence of attentional vigilance towards the critical items. If the critical item attracted the viewer's attention, one would expect a reduction in the attentional resources available for the cross-line discrimination task, thereby leading to poorer performance on the cross-line discrimination task among those who detected/identified the critical item. The accuracy of the cross-line discrimination was compared between detectors and non-detectors (also between identifiers and non-identifiers). Consistent with expectation, relative to non-detectors, detectors showed a poorer performance on the inattentional (no. 4; Fisher's Exact Test, $p = .040$) and divided attention (no. 8, Fisher's Exact Tests, $p = .009$) trials; whereas they did not differ on regular trials (no. 1, 2, 3, 5, 6, 7, and 9). Likewise, relative to non-identifiers, identifiers showed a non-significant trend toward poorer performance on the inattentional trial, Fisher's Exact Test, $p = .075$, and a significantly poorer performance on the divided attention trial, Fisher's Exact Test, $p = .015$ (see Table 5).

Discussion

Mack and Rock (1998) argued that perception occurs only when attention is engaged in the target object. It follows that even an object being directly looked at can evade perception if it receives insufficient attention. The failure to perceive a stimulus despite its foveal presentation due to lack of attention is the essence of the IB phenomenon. Conversely, the perception of an object placed under conditions of limited attention demonstrates hypervigilant attentional processing. Considering the convincing prior evidence indicating that the perception of the unanticipated critical stimulus is strongly influenced by its meaningfulness (Mack, 2003; Mack & Rock, 1998), our findings from identification rates suggest that frowning faces are more likely to have greater signal value to HSAs faced with a social-evaluative challenge, leading to hypervigilant processing. In the presence of the bogus-speech threat, HSAs were more than twice as likely to identify the frowning face relative to LSAs (61.9% vs. 26.1%), whereas LSAs were more likely to identify the smiling face relative to HSAs (60.0% vs. 40.0%).

In contrast to findings for identification rates, rates of detection were not significantly influenced by participants' dispositional social anxiety. This discrepancy may be a function of the deeper level of attentional processing required for identification. One possibility is that the relatively shallow attentional processing may be enough for the simple schematic icon to be detected, and accordingly the impact of the current contextual cue (i.e., the imminent social threat) on the face's signal value may have overridden any effects of dispositional social anxiety. In contrast, identifying faces is likely to require greater attentional resources for more extensive perceptual and semantic processing, in which the impact of the contextual cue may be moderated by participants' dispositional social anxiety. Future research on the underlying mechanisms governing the detection and identification of emotional faces is needed.

The current data also suggest the possibility that LSAs may be characterized by a positively biased perceptual compensation when forming an imperfect perceptual representation. When the sad face was presented under the bogus-speech threat, of the 16 HAS detectors (out of 21), 81.3% ($N = 13$) identified it. In contrast, of the 16 LSA detectors (out of

[2] We used the same analytic procedures applied to the data from the inattentional trial in order to test the hypothesis that the interaction effect among the three factors would not be present for the detection/identification rates of the divided and full attentional trials due to an increase in attentional resources allocated to the possible presence of an extra object. As predicted, the three-way interaction was not observed for the two subsequent critical trials. In the divided attentional trial, only main effects for the critical item condition emerged showing (a) that the emotional faces were detected better than the neutral object and (b) that the positive face was identified better than the negative face or the neutral object. The full attentional trial yielded neither main nor interactional effect.

23), only 37.5% ($N = 6$) identified it. Interestingly, of the 10 LSA misidentifiers, nine (spontaneously) reported having seen a happy face and also chose a happy face in the object array during the recognition test (one person reported having seen a circle). Perhaps LSAs compensated for their incomplete percept with some positively oriented top-down encoding process. We believe that the observed misidentification of the sad face among LSAs reflects a perceptual failure caused by insufficient attentional engagement rather than an interpretation bias. Once attention was sufficiently engaged (i.e., divided and full attention trials), most of the LSAs under the bogus speech threat correctly identified the sad face. Taken together, these findings suggest that LSAs are more likely to preferentially process favorable social cues, whereas HSAs are more likely to process potentially threatening social cues in a hypervigilant fashion when anticipating a social-evaluative situation.

One might argue that the reliance on the object array presenting emotionally valenced items might have introduced a response bias in the identification test. We computed identification rates excluding those who merely guessed at the critical item on the object array after failing to detect it. However, it may still be possible that the selection on the object array was differentially affected by the level of social anxiety such that HSAs might have preferred to select the frowning face, while LSAs preferred to select the smiling face. To examine this possibility, we conducted two additional analyses. First, we compared the *guesswork* of HSA vs. LSA non-detectors in the identification test. Of the 70 LSA non-detectors, 22 selected the smiling face and four selected the frowning face. Similarly, of the 66 HSA non-detectors, 21 selected the smiling face and four selected the frowning face. Secondly, we also examined the object-array selection of those who detected the neutral critical item (i.e., circle). Of the 11 LSA detectors of the circle, seven selected the circle, three selected the smiling face, and one selected the frowning face. Of the 10 HSA detectors, eight selected the circle, and two selected the smiling face. These findings suggest that the selection of emotional faces did not differ as a function of the level of participants' social anxiety.

Some limitations of Experiment 1 should be noted. First, schematic icons may not be as potent social cues as facial pictures. The emotional valence of the frowning face also seems rather unclear (i.e., sad, angry, frustrated, etc.). However, it was important to retain the original stimulus parameters in Mack and Rock (1998) given our first application of this paradigm to the investigation of attentional bias. The use of the schematic versions also makes the smiling and frowning faces equivalent in terms of their deviation from an expressionless neutral face, thereby balancing their perceptual salience and removing a potential happy-face advantage (see Leppänen & Hietanen, 2004). Secondly, it is rather problematic that the main study findings were derived only from identification rates, although there is no direct evidence indicating the presence of response bias in the identification phase. This may be related to the low potency of facial icons.

Experiment 2

Although Experiment 1 provided encouraging support for the potential utility of the IB paradigm in attentional bias investigation, several limitations prompted us to conduct another experiment. For example, despite its success in helping to identify stimulus properties that attract attention, the short stimulus presentation inherent in the static IB task has raised concerns, For instance, Wolfe (1999) has put forward the possibility that IB may not reflect a perceptual failure caused by a lack of attention, but rather a memory failure resulting from instantaneous forgetting of the detected object. Studies using a rapid stimulus presentation method have shown that rapidly presented pictures may be identified within 125 ms, but the consolidation into explicit memory may require approximately 300 ms (Potter, 1976; Potter & Levy, 1969). Relatedly, Most et al. (2001) have suggested that the short stimulus duration of the static IB makes the testing situation far removed from the full range of dynamic and sustained images that we face in our day-to-day lives.

Thus, based on the sustained IB paradigm, we designed an IB task incorporating several methodological advances absent in Experiment 1. These included: (a) use of more dynamic and sustained visual stimuli lasting for a total of 15 s; (b) longer presentation duration of the critical item (i.e., 5 s); and (c) use of more ecologically relevant emotional stimuli (i.e., Ekman's angry and happy faces).

The dominant factor governing attentional capture in the sustained IB paradigm was found to be the perceptual match between the critical item and the viewer's attentional set (Most et al., 2005). Entering a social-evaluative situation, HSAs are likely to readily activate or maintain a hypervigilant attentional set attuned to negative social cues, whereas LSAs are likely to activate attentional set attuned to favorable social cues (Rapee & Heimberg, 1997). The viewer's attentional set was expected to be strongly influenced by both dispositional social anxiety and contextual social threat. Accordingly, Experiment 2 sought to test the same set of hypotheses as those in Experiment 1, including the three-way interaction between social anxiety status, critical items, and the bogus-speech manipulation, based on this attentional-set matching account.

Method

Participants

Undergraduate students ($N = 2350$) enrolled in introductory psychology courses at the University of Texas at Austin were screened using the FNES. Those who scored 10 or below (LSAs; $N = 714$) or 22 or higher (HSAs; $N = 693$) were invited to participate in the experiment in partial fulfillment of their experimental credit. Of those, 305 students replied to the invitation. Upon retesting, 45 participants no longer met the FNES criteria. The final sample consisted of 261 students (97 males, 164 females, mean age = 18.82 years, SD = 1.66). They were ethnically diverse: Caucasian (58.2%), Hispanic (21.1%), Asian/Pacific Islander (11.5%), African American (5.4%) and other (3.4%).

Experiment materials

The IB task was designed in line with the typical structure of sustained IB tasks presenting five 15-s judgment trials (Most et al., 2001, 2005). Subjects were seated at a comfortable distance from a 17 inch computer monitor (on average, about 35 cm). On each trial, four black squares and four light gray ovals moved on (predetermined) haphazard paths at a variable speed ranging from 2 to 5 cm/s, occasionally occluding each other or bouncing off the edges of the 13 cm × 18 cm gray display with a small central cue. These distracters had a height and width of approximately 1 cm.

On each trial, subjects were asked to fixate on the central cue and count the number of times the four *black squares* bounce off the edges. The first two trials were regular judgment trials. The third, fourth, and the fifth and last trial corresponded to the inattentional, divided attention, and full attention condition, respectively. Five seconds into each of the critical trials, the critical item entered the middle of the right side of the display and moved left and exited the display during the next 5 s period. Critical items included a happy face, an angry face, and a light gray oval. They were in the shape of an oval with the same size and overall luminance. To generate gender-neutral critical items, one male and one female face from Ekman's facial stimuli (Ekman, 1976; Ekman & Friesen, 1984) were averaged using image-morphing software (Morpheus Photo Morpher v3.00).

Procedure and design

Experiment 2 followed the same study procedure as Experiment 1 using the identical 2 × 3 × 2 factorial design. In the inattentional and divided attention trials, the regular judgment performance was followed by additional probing questions and a recognition test using an object array (see Fig. 3) in the same fashion as Experiment 1. The full attention trial asked the subjects to simply watch the display without monitoring the squares. The study measures were identical to those in Experiment 1. Experiment data were subject to the same analytic procedures based on hierarchical logistic regression analyses.

Statistical power to detect differences in detection and identification rates. Power analyses were conducted in the same fashion as Experiment 1. Our power to detect a medium effect size in the hypothesized direction with the current sample size and setting α at .05 (one-tailed) was .73.

Results

Group characteristics

Table 3 presents means and standard deviations of the demographic and clinical measures across the 12 experimental conditions. Compared with LSAs, HSAs consisted of more females (70% vs. 56%), χ^2 (1) = 5.25, $p = .022$. HSAs also scored significantly higher than LSAs on the FNES (mean = 25.89 vs. 5.15), $t(259) = 63.34$, $p < .001$; SPS (mean = 27.16 vs. 8.28), $t(259) = 16.25$, $p < .001$; SIAS (mean = 35.53 vs. 13.86), $t(259) = 17.81$; $p < .001$; BDI (mean = 10.90 vs. 3.38), $t(259) = 10.47$, $p < .001$; and STAI-trait (mean = 48.57 vs. 34.00), $t(259) = 17.18$, $p < .001$. No difference was observed in the demographic and clinical measures between the two bogus-speech manipulation or the three critical item conditions.

Bogus-speech manipulation check

Pre- and post-manipulation anxiety scores were compared between the two bogus-speech conditions. The two groups did not differ in their pre-manipulation state anxiety scores (bogus-speech condition—mean = 30.39, SD = 18.70; no bogus-speech condition—mean = 26.25, SD = 17.42; $t(259) = 1.85$, $p = .066$); whereas those who received the bogus-speech threat reported higher anxiety scores (mean = 40.30, SD = 24.28) compared with those who did not (mean = 22.72, SD = 16.51), $t(259) = 6.86$, $p < .001$. Moreover, pre- to post-state anxiety scores increased for the bogus-speech condition, $t(127) = 7.64$, $p < .001$, but decreased for the no bogus-speech condition, $t(132) = -4.35$, $p < .001$ (see

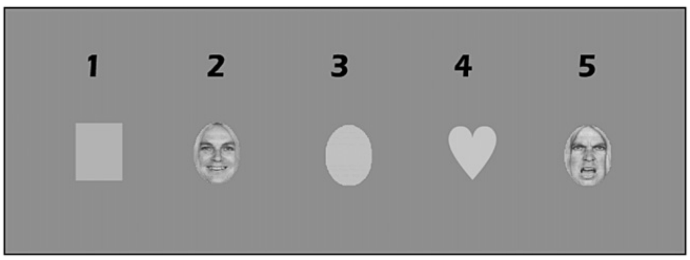

Fig. 3. Object array for the recognition test in Experiment 2.

Table 3
Demographic variables, clinical measures, and pre- and post manipulation state anxiety scores across 12 groups in Experiment 2

	No speech						Bogus speech					
	Happy		Angry		Circle		Happy		Angry		Circle	
	LSAs ($N = 27$) M (SD)	HSAs ($N = 24$) M (SD)	LSAs ($N = 27$) M (SD)	HSAs ($N = 26$) M (SD)	LSAs ($N = 15$) M (SD)	HSAs ($N = 14$) M (SD)	LSAs ($N = 24$) M (SD)	HSAs ($N = 25$) M (SD)	LSAs ($N = 24$) M (SD)	HSAs ($N = 25$) M (SD)	LSAs ($N = 15$) M (SD)	HSAs (N = 15) M (SD)
Age	18.37 (0.74)	18.83 (1.46)	19.48 (3.48)	18.69 (1.19)	18.93 (1.10)	18.71 (0.73)	19.13 (2.07)	18.80 (1.61)	18.42 (0.65)	18.44 (0.71)	19.40 (1.55)	18.80 (1.52)
Gender (% male)	44	25	44	35	40	29	46	28	46	32	40	33
FNES	5.48 (2.12)	25.71 (1.63)	5.26 (2.94)	26.65 (2.65)	5.33 (3.42)	24.57 (2.59)	4.88 (2.53)	25.96 (2.91)	4.42 (2.87)	25.88 (1.97)	5.80 (3.53)	26.00 (2.80)
SPS	8.59 (5.44)	25.54 (11.84)	9.48 (7.73)	27.96 (10.52)	7.40 (6.80)	24.50 (9.59)	8.04 (5.57)	27.68 (11.06)	6.29 (4.46)	26.64 (10.03)	10.00 (10.80)	30.80 (16.67)
SIAS	14.30 (5.72)	34.13 (10.35)	14.44 (8.97)	36.62 (13.26)	13.67 (7.79)	29.29 (9.50)	13.71 (5.84)	39.44 (11.01)	10.92 (4.84)	34.36 (11.13)	17.13 (12.03)	37.13 (13.35)
BDI	2.78 (3.03)	9.42 (4.83)	3.74 (4.18)	13.27 (7.38)	4.13 (6.82)	7.14 (5.08)	3.17 (2.51)	12.04 (9.15)	2.25 (2.25)	9.32 (5.83)	5.20 (4.96)	13.40 (8.54)
STAI	32.85 (3.07)	48.83 (5.85)	34.81 (5.03)	51.46 (8.17)	31.47 (4.37)	44.14 (6.60)	34.75 (5.59)	48.04 (8.92)	33.67 (4.68)	48.32 (7.68)	36.47 (7.20)	48.53 (11.73)
Pre-anxiety	19.93 (11.50)	30.67 (18.19)	18.00 (10.97)	37.74 (20.23)	18.13 (14.19)	34.14 (17.91)	24.08 (15.81)	43.36 (18.81)	17.75 (9.86)	33.84 (16.49)	22.00 (17.20)	41.67 (18.90)
Post-anxiety	14.81 (7.83)	26.75 (14.52)	15.41 (15.03)	36.08 (19.74)	12.81 (8.57)	31.00 (13.35)	29.62 (19.23)	52.32 (21.51)	23.67 (14.04)	47.92 (21.39)	28.13 (22.46)	63.47 (23.85)

Table 3). Overall, relative to LSAs, HSAs displayed a greater increase in anxiety in response to the bogus-speech threat. These data suggest that the bogus speech task was successful in producing a significant increase in state anxiety.

Differences in detection rates for the inattentional trial

Hierarchical logistic regression analyses were conducted entering the three main effects (i.e., social anxiety status, critical item condition, and bogus-speech manipulation) in Step 1, the three two-way interaction terms in Step 2, and the three-way interaction term in Step 3. Table 4 presents the detection rates in the inattentional trial across the 12 experimental groups. In Step 1, there was a main effect only for the critical item condition: (a) the happy face was detected better than the oval (58.0% vs. 3.4%), $B = 3.68$, Wald = 24.21, $p < .001$, odds ratio = 39.61, 95% CI [9.15, 171.50]; and (b) the angry face was also detected better than the oval (58.8% vs. 3.4%), $B = 3.72$, Wald = 24.71, $p < .001$, odds ratio = 41.08, 95% CI [9.49, 177.79]. In Step 2, none of the two-way interaction terms were significant. In Step 3, the three-way interaction term involving the contrast between the happy and angry faces was significant above and beyond the main effects of the three individual predictors and their two-way interactions, $B = 2.53$, Wald = 4.71, $p = .030$, odds ratio = 12.59, 95% CI [1.28, 123.85]. To further probe this three-way interaction, the two-way critical item by social anxiety status interaction was examined for each level of the bogus-speech manipulation. Results revealed a significant critical item (happy vs. angry face) by social anxiety status interaction only for those under the bogus-speech threat, $B = 1.71$, Wald = 4.09, $p = .043$, odds ratio = 5.54, 95% CI [1.06, 29.09]. Under the bogus speech threat, there was a non-significant trend that HSAs outperformed LSAs in detecting the angry face (72.0% vs. 54.2%), Fisher's exact test, $p = .159$; whereas LSAs outperformed HSAs in detecting the happy face (66.7% vs. 44.0%), Fisher's exact test, $p = .095$. In contrast, in the absence of the bogus-speech threat, there was a non-significant trend for LSAs to detect the angry face better than HSAs (63.0% vs. 46.2%), Fisher's exact test, $p = .170$.

The nature of the observed three-way interaction was also examined by comparing the happy vs. angry face conditions separately for LSAs and HSAs. Under the bogus-speech threat, HSAs detected the angry face better than the happy face (72.0% vs. 44.0%), Fisher's exact test, $p = .042$. In contrast, in the absence of the bogus-speech threat, there was a

Table 4
Detection and identification rates of the three critical trials across the 12 Experiment groups in Experiment 2

	No speech						Bogus speech					
	Smiling		Frowning		Circle		Smiling		Frowning		Circle	
	LSAs	HSAs	LSAs	HSAs	LSAs	HSAs	LSAs	HSAs	LSAs	HSAs	LSAs	HSAs
Inattentional												
Detection rate (%)	59.3	62.5	63.0	46.2	.0	7.1	66.7	44.0	54.2	72.0	6.7	.0
Identification rate (%)	48.1	54.2	40.7	46.2	.0	7.1	58.3	44.0	29.2	64.0	6.7	.0
Divided attention												
Detection rate (%)	88.9	83.3	92.6	92.3	26.7	35.7	95.8	88.0	83.3	100.0	26.7	26.7
Identification rate (%)	81.5	75.0	85.2	73.1	26.7	35.7	91.7	88.0	54.2	72.0	26.7	26.7
Full attention												
Detection rate (%)	100.0	100.0	100.0	100.0	93.3	100.0	100.0	100.0	95.8	100.0	100.0	100.0
Identification rate (%)	100.0	100.0	96.3	100.0	93.3	100.0	95.8	96.0	95.8	100.0	100.0	100.0
Overall counting error												
M	1.88	2.22	1.97	2.03	1.93	1.32	2.15	2.23	1.92	2.05	2.08	2.10
(SD)	(1.13)	(1.48)	(.93)	(1.45)	(1.26)	(.67)	(1.35)	(1.45)	(.85)	(1.14)	(.67)	(.69)

non-significant reverse trend for HSAs to detect the happy face better than the angry face (62.5% vs. 46.2%), Fisher's exact test, $p = .191$.

Differences in identification rates for the inattentional trial

With respect to identification rates in the inattentional trial, Step 1 revealed a significant main effect for the critical item condition: (a) the happy face was identified better than the oval (51.0% vs. 3.4%), $B = 3.40$, Wald $= 20.73$, $p < .001$, odds ratio $= 30.06$, 95% CI [6.95, 130.10], and (b) the angry face was also identified better than the oval (45.5% vs. 3.4%), $B = 3.16$, Wald $= 17.92$, $p < .001$, odds ratio $= 23.63$, 95% CI [5.46, 102.19]. In Step 2, none of the two-way interaction terms were significant. In Step 3, the three-way interaction term involving the contrast between the happy and angry faces was marginally significant, $B = 2.06$, Wald $= 3.19$, $p = .074$, odds ratio $= 7.85$, 95% CI [.82, 75.50]. Although this interaction did not reach statistical significance, the effect was in the predicted direction and the odds ratio's effect size was large (Rosenthal, 1996). Indeed, this three-way interaction was statistically significant when looking into the unique contribution of dispositional social anxiety and contextual threat cue by partialling out the influence of general emotional distress, $B = 2.37$, Wald $= 4.03$, $p = .045$, odds ratio $= 10.68$, 95% CI [1.06, 107.77]. To further probe this three-way interaction trend, the two-way critical item by social anxiety status interaction was further examined for each level of the bogus-speech manipulation. Results revealed a significant critical item (happy vs. angry face) by social anxiety status interaction only for those under the bogus-speech threat, $B = 2.04$, Wald $= 5.87$, $p = .015$, odds ratio $= 7.69$, 95% CI [1.48, 40.07]. In the presence of the bogus-speech threat, HSAs outperformed LSAs in identifying the angry face (64.0% vs. 29.2%), Fisher's exact test, $p = .015$. In contrast, LSAs identified the happy face better than HSAs, which, however, did not reach statistical significance (58.3% vs. 44.0%), Fisher's exact test, $p = .237$. In the absence of the bogus-speech threat, HSAs and LSAs did not differ in identifying the faces.

Additional analyses also showed that LSAs who received the bogus-speech threat identified the happy face significantly better than the angry face (58.3% vs. 29.2%), Fisher's exact test, $p = .040$. In contrast, there was a non-significant trend for HSAs to identify the angry face better than the happy face (64.0% vs. 44.0%), Fisher's exact test, $p = .128$. In contrast, no significant difference in the identification rates between the happy face vs. angry face was observed for both LSAs and HSAs assigned to the no bogus-speech condition (LSAs—48.1% vs. 40.7%, Fisher's exact test, $p = .392$; HSAs—54.2% vs. 46.2%, Fisher's exact test, $p = .389$).

Differences in perceptual accuracy or attentional investment?

We also considered the possibility that the observed group differences may be due to differential perceptual accuracy or attentional investment by examining bounces-counting errors across the 12 experiment groups. The counting error for each trial was determined by taking the absolute number of difference between the reported number of bounces and the correct number of bounces made by the four black squares. The overall counting error for the entire sample was 2.01 (SD = 1.16) and there were no significant differences across the 12 experimental groups.[3]

[3] See Footnote 2.

Table 5
Differences between detectors and non-detectors in performance on the distracter task

	Detectors	Non-detectors	Identifiers	Non-identifiers
Experiment 1: proportions (%) of correct responders				
Trial 1	62.9	63.2	61.1	64.3
Trial 2	77.9	75.0	76.9	76.2
Trial 3	80.7	78.7	79.6	79.8
Trial 4 (inattentional)	77.1	86.0	76.9	84.5
Trial 5	69.3	67.6	72.2	66.1
Trial 6	67.9	65.4	69.4	64.9
Trial 7	85.7	80.9	85.2	82.1
Trial 8 (divided attention)	67.9	80.9	66.7	79.2
Trial 9	69.3	64.7	67.6	66.7
Experiment 2: average number of counting errors with standard deviations				
Trial 1	3.08 (2.39)	2.84 (2.36)	3.18 (2.44)	2.81 (2.32)
Trial 2	1.40 (1.29)	1.31 (1.22)	1.38 (1.35)	1.33 (1.19)
Trial 3 (inattentional)	2.38 (1.91)	1.77 (1.56)	2.36 (1.90)	1.86 (1.63)
Trial 4 (divided attention)	1.74 (1.50)	1.65 (1.44)	1.74 (1.48)	1.67 (1.46)

Additional evidence of vigilant attention towards the critical item

We examined if the bounce-counting distracter task yielded a secondary index of attentional vigilance towards the critical items. Similar to Experiment 1, detectors and non-detectors (determined from the inattentional trial) did not differ in counting errors on the first two regular trials (trial no. 1 mean error = 3.08 vs. 2.84, $t(259) = .837$, $p = .403$; trial no. 2 mean error = 1.40 vs. 1.31, $t(259) = .565$, $p = .573$). In contrast, relative to non-detectors, detectors committed significantly greater errors on the third (inattentional) trial (mean error = 2.38 vs. 1.77; $t(259) = 2.84$, $p = .005$). A similar pattern of findings was observed for identifiers vs. non-identifiers from the inattentional trial (See Table 5). These data suggest that the unexpected object cannot be perceived without taxing the viewer's attentional resources that would otherwise be devoted to the distracter task.

Discussion

The attentional set matching account suggests that what the viewer has set his/her mind to see (i.e., attentional set) is paramount with respect to the perception of an unanticipated object in the sustained IB task. The present experiment showed a different pattern of interplay between dispositional social anxiety and contextual threat cue in response to the unexpectedly presented happy vs. angry faces: the angry face was more likely to be noticed among HSAs relative to LSAs in the presence of a social-evaluative threat, and vice versa for the happy face. From the standpoint of the attentional set matching account (Most et al., 2005), our data suggest that HSAs are more apt to activate an attentional set attuned to negative social cues leading to hypervigilant processing particularly when faced with a social-evaluative situation. In contrast, LSA's attentional set is more likely to be attuned to benign social cues leading to preferential attentional processing of these non-threatening cues. These findings were not accounted for by general emotional distress or demographic variables such as age or gender. Nor did differential perceptual accuracy explain varying detection and identification rates. Overall, our data provide evidence of attentional bias in social anxiety in the form of hypervigilance towards potentially negative social cues, which is likely to be activated in the context of social-evaluative threat.

Our data also support an attentional set matching account as opposed to an alternative stimuli-salience account. Compared with the eight distracters, the emotional faces contained several salient features such as unique surfaces, gradations, protrusions, internal facial components, and the uniquely straight motion path. Had the stimulus salience been the factor governing the detection of critical items, HSAs and LSAs should not have differed in noticing the emotional faces because the two faces shared most of these salient physical features. Rather, the observed differences between the happy and angry faces suggest the operation of some top-down process reflecting the influence of dispositional social anxiety and perceived social-evaluative threat.

We also found a noticeable drop in the identification rates among LSAs who were presented with the angry face. From Fig. 4, one can infer (a) that the hypothesized attentional-set matching process might have prevented LSAs from allocating sufficient attention towards the angry face relative to the happy face, and (b) HSAs seem to have processed emotional faces more efficiently than LSAs given the overall lesser degree of misidentification among HSAs. LSAs' low dispositional social anxiety may have tuned their attentional set to more benign/positive social cues and thus hampering the processing of the negative social cue. It is unlikely that LSAs' misidentification of the angry face is attributable to a response bias that would have led subjects to preferentially process the emotional faces according to the level of their social anxiety. In the inattentional trial, HSA non-detectors and LSA non-detectors did not differ in guessing the critical item from the object

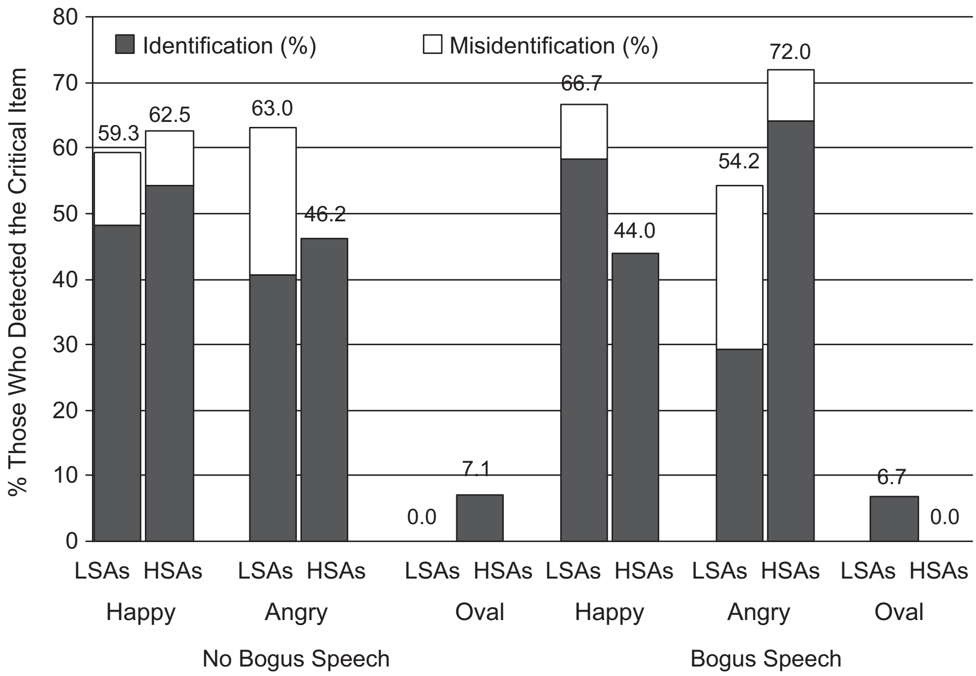

Fig. 4. Detection rates from the inattentional trial in Experiment 2.

array (of 66 LSA non-detectors, five chose the happy face and one selected the angry face; of 68 HAS non-detectors, four chose the happy face and two selected the angry face). Further investigation is needed to illuminate the attentional process that may hinder correct identification of emotional faces in the attentionally limited condition.

Experiment 2 also revealed that non-detectors were more accurate than detectors in the bounce-counting distracter task. The IB paradigm provides the opportunity to distinguish between the interference (i.e., attentional allocation) towards the primary task and attentional vigilance towards the threat stimuli. Future research may include a control group that undergoes only regular discrimination trials in order to directly test the effect of the presence vs. absence of the critical item.

Taken together, this experiment demonstrated the promising utility of the sustained IB task in investigating attentional biases in social anxiety, presenting several methodological strengths: (a) reducing strategic or effortful reactions, (b) use of emotional faces as the unanticipated search target, (c) delivery of the emotional cue tapping the core of social anxiety, (d) more realistic and sustained viewing condition, thus enhancing ecological validity, and (e) provision of a secondary measure of attentional deployment (i.e., performance on the distracter task).

General discussion

The cost of failing to see an unexpected object can be quite consequential at times. As noted by Most et al. (2005), many traffic accidents seem to be caused by drivers' obvious failure to detect obstacles placed in front of their eyes. Conversely, some clinical conditions such as anxiety disorders are characterized by enhanced *detection* of potentially threatening cues. This seems particularly true in the case of social anxiety disorder, in which hypervigilance is suspected to play a central role in its maintenance (Rapee & Heimberg, 1997). The overall pattern of our data suggests the presence of hypervigilance in social anxiety that is likely to be activated in response to social-evaluative cues. Our data provide support for Rapee and Heimberg's (1997) model of social anxiety that posits that social anxiety is associated with rapid and extensive attentional allocation towards potential social threats. Considering the clinical relevance of the IB paradigm that can directly examine how the social cue itself is perceived, as well as its several methodological strengths, the current data may present (a) a robust demonstration of hypervigilance implicated in social anxiety, and (b) evidence supporting its utility as a vehicle for measuring attentional biases in social anxiety.

One intriguing question arising from the IB phenomenon is how participants fail to see the emotional face if they have *already* checked its meaning or properties. This may be explained by the *implicit* and *automatic* attentional shift to the unexpected item, which is followed by some top-down filtering/matching mechanism that determines whether the unexpected item would undergo further attentional processing. In a sustained IB experiment with a no critical item control condition, Most et al. (2005) found that the emergence of the critical item led to a significant reduction in counting accuracy for *non-detectors* compared with controls, although the greatest decrease was observed among detectors. These findings led them to suggest that an implicit shift of attention may precede the awareness of an unexpected object that appears during an attentionally demanding task. The entirety of perceptual representation of the stimulus may depend on the extent to which further attentional processing ensues. This may also explain the greater tendency to misidentify the detected negative face among HSAs, relative to LSAs.

From this vantage point, the current findings may be rephrased more specifically as follows: (1) relative to LSAs, HSAs are more likely to sustain the implicitly shifted attention towards potentially negative (as opposed to positive) social cues (i.e., *hypervigilant orienting*). Individuals high in social anxiety may be more apt to deploy their attention to potentially threatening cues emerging in social situations even in attentional-limited conditions. (2) Relative to LSAs, HSAs are likely to engage in more extensive attentional processing towards potentially negative (as opposed to positive) social cues, forming a more veridical percept of the social cues (i.e., *more extensive processing leading to better awareness*). Thus, individuals high in social anxiety are more likely to perceive potentially threatening social cues even under conditions in which attention is limited.

The modified dot-probe paradigm examines only a limited facet of attentional processing, namely, the *orientation* of relatively early (typically 500 ms) attentional deployment *forced* between two paired stimuli, without accounting for how the social cue itself was attentionally processed. Some (e.g., Cooper & Langton, 2006) have argued this attentional deployment is not early enough. Paired stimuli may also make it difficult to infer underlying response mechanisms leading to varying detection speed (i.e., one item attracting attention, another item inhibiting attention, or both?). The dot-probe paradigm provides no information on how individuals (negatively) process social cues themselves that may often take place unexpectedly, which seems an important focus of cognitive intervention. Taken together, the IB paradigm seems capable of assessing the multifaceted nature of attentional processing, yielding clinically relevant and informative indices of attentional bias while reducing potential strategic or effortful responses.

The role of state vs. trait social anxiety in attentional bias investigation

Both Experiments 1 and 2 revealed a different pattern of interplay between dispositional social anxiety and emotional faces as a function of the bogus-speech threat manipulation. What is the role of this commonly used manipulation in attentional bias investigation? Generally, it has been regarded as serving to temporarily heighten state anxiety. Accordingly, most studies (e.g., Mansell et al., 1999; Sposari & Rapee, 2007), including the present one, have checked the success of the procedure by assessing changes in levels of state anxiety before and after its administration. To date, findings are equivocal concerning the effects of speech threat. For example, Chen et al. (2002) demonstrated attentional avoidance from faces with a clinical sample using a modified dot-probe task *without* a bogus-speech manipulation and argued that this manipulation is not necessary with clinical samples of SAD patients due to their already heightened sensitivity to social evaluation. However, a recent replication study that included the bogus-speech manipulation (Sposari & Rapee, 2007) found a greater *vigilance* for faces in patients with SAD, relative to normal controls. Thus, it appears that the presence of speech threat affects attentional processing regardless of the clinical status of subjects. This also suggests the possibility that the primary role of the bogus-speech manipulation may not be to heighten state social anxiety/sensitivity but rather to activate a social-evaluative cognitive schema.

Cognitive models of social anxiety posit the impact of negative social beliefs originating from early experience (i.e., schema) on biased information processing of social cues (Clark & Wells, 1995; Rapee & Heimberg, 1997). Schemas are deep mental structures serving as a cognitive framework to organize and process information (Bartlett, 1932; Mandler, 1984). Particularly, a maladaptive social schema may lead the individuals to selectively attend to negative social cues or misinterpret the meaning of ambiguous or neutral social cues in a way confirming their negative schema. In both Experiments 1 and 2, identification rates from the inattentional trial showed the tendency that the preferential processing for the happy face in the case of LSAs, and the angry face in the case of HSAs was more prominent when the speech threat was introduced (see Figs. 2 and 4). It may be that the bogus-speech threat helped amplify underlying cognitive style via the activation of cognitive schema related to social-evaluative cues. HSAs' schema may be replete with threatening themes centering around embarrassment, shame, and social failure; whereas that of LSAs may depict more favorable social interactions (Clark & Wells, 1995; Rapee & Heimberg, 1997). Thus, the bogus speech threat is expected to exert differential influence on attentional processing according to the level of dispositional social anxiety. The activated schema may also strongly affect what one would perceive as meaningful or what one would be ready to see in social situations. In future studies, it would be worthwhile to assess how social-cognitive schemas are activated by the presence of a social threat and affects attentional processing.

Limitations

Some limitations of the present study should be noted. First, the generalizability of our findings to a clinical sample cannot be assumed. Replication with clinical samples of patients with social phobia is needed. Particularly, it would help establish the specificity of current findings to pursue clinical replication including different diagnostic groups of anxiety disorders or depression. Second, some discrepancies in findings from Experiments 1 and 2 (e.g., the impact of dispositional social anxiety on detection rates) remained unexplained due to their methodological differences including: (a) the nature of the distracter task, (b) stimulus duration and mobility, and (c) the nature of critical items (schematic icons vs. face pictures). It is important to systematically examine the role of task parameters to elucidate the differences between these two IB paradigms. Future studies may also consider employing the static IB task using facial pictures as critical items. This may enhance the sensitivity of the task to reveal the effect of dispositional social anxiety on detecting social cues. Third, several of our Fisher's exact tests that followed significant interaction effects showed non-significant trends due to relatively low statistical power to detect less than medium-sized effects (differences in detection/identification rate smaller than .25). Finally, it is important to note that the IB paradigm hinges on a completely crossed between-subjects design, which necessitates relatively large samples and renders its application for evaluating attentional bias on an individual level unsuitable. This paradigm may best be utilized to test cognitive theories or models of psychopathology via examining attentional processing on a group level.

Conclusions

Understanding the nature of biased attentional processing is likely to advance our models for the maintenance of social anxiety, which in turn may help guide the development of more potent treatment strategies. The present study demonstrated the potential utility of the IB paradigm. Its sensitivity in capturing attentional vigilance while reducing strategic or effortful responses makes the IB paradigm a useful addition to existing paradigms for assessing biased attention in social anxiety and perhaps other forms of psychopathology as well.

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