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Abstract

We investigated the effects of awareness on selective attention for masked and unmasked verbal threat material using a computerised version of the emotional Stroop. Participants were assigned to the high trait anxious (HTA) and low trait anxious (LTA) groups on the basis of questionnaire scores, and state anxiety was manipulated within participants through the threat of electric shock. To investigate the effects of awareness on responses to threat, the mode of exposure was blocked such that half the participants received masked trials before the unmasked trials, whereas the other half received the reverse order. The results revealed that there was no difference between the HTA and LTA groups in responses to threat for those who received the masked trials before the unmasked trials. However, when unmasked trials were presented before the masked trials HTA individuals were significantly slower to respond to both masked and unmasked threat words compared to the LTA group, and these effects were not further modified by participants' state anxiety status. The results are discussed in terms of the automatic nature of threat processing in anxiety.

Keywords: selective attention, emotional Stroop, threat words, backward masking, anxiety, awareness.

Selective Attention for Masked and Unmasked Threatening Words in Anxiety: Effects of Trait Anxiety, State Anxiety and Awareness

Prominent cognitive theories of emotional processing propose that anxiety is characterised by a bias to attend to threat-related information, and that this bias is likely to proceed without volition and without awareness within the attentional system (e.g., Mogg & Bradley, 1998; Williams, Watts, MacLeod & Mathews, 1988, 1997). These models also suggest that biases for threat are not limited to individuals with clinical anxiety diagnoses in that they are thought to operate in a similar fashion for non-clinically high trait anxious individuals who experience high levels of state anxiety. Because threat-related processing biases are thought to be an important causal and maintaining factor for anxiety disorders (e.g., Williams, Mathews & MacLeod, 1996; Williams et al., 1997) research into the conditions that elicit them has considerable clinical implications.

Interference paradigms have been the most extensively used procedures for investigating threat-related processing biases in anxiety. For example, in the emotional Stroop paradigm, anxious participants and non-anxious controls are presented with threat words (e.g., panic, danger) and neutral words (e.g., table, chair) in letter strings of one colour (e.g., red, green, blue, yellow), and the participants' primary task is to name the colour of the lettering as quickly as possible while ignoring the semantic content of the items. The extent to which colour naming latencies for threat words differ from those of non-threat words is taken as a measure of selective attention for threat. The results from a number of studies using the emotional Stroop procedure have shown that relative to non-anxious controls, anxious participants are slower to name the colour of threat words than neutral words, presumably because the content of the item interferes with performance on the colour naming task. Threat related biases have shown to be associated with a variety of clinical anxiety disorders including PTSD (e.g., Harvey, Bryant & Rapee, 1996), panic disorder (e.g., Lundh, Wikström, Westerlund & Öst, 1999; McNally, Riemann & Kim, 1990), GAD (e.g., Bradley, Mogg, Millar & White, 1995; Mogg, Bradley, Williams & Mathews, 1993), OCD (e.g., Cohen, Lachenmeyer & Springer, 2003), and generalised social phobia (Amir, Freshman & Foa, 2002), and in non-clinical high trait anxious individuals who experience elevations in state anxiety (e.g., Edwards, Burt & Lipp, 2006; Miller & Patrick, 2000). Importantly, because participants are instructed to ignore the meaning of the item and to name the colour as quickly as possible, these data suggest that selective threat bias effects might operate automatically, at least in the sense that they occur without volition.

There is also a large body of data that suggests threat-processing biases might proceed without awareness. The most convincing evidence for this interpretation has come from studies employing backward masking procedures. This protocol involves presenting participants with neutral and threat-related words for a brief period (e.g., 14 ms), and at their offset a pattern mask consisting of letter fragments or random consonant strings is presented in the location previously occupied by the item. Awareness assessments are carried out using forced-choice lexical decision tasks in which participants are asked to choose whether a true word or non-word was presented before the mask. Despite chance performance in determining the lexical status of the item before the mask, a number of studies have reported data showing that relative to non-anxious controls, anxious individuals are slower to name the colour of masked threat words compared to masked non-threat control words. These effects have been reported in clinically anxious samples (e.g., Bradley et al., 1995; Foa, Feske, Murdock, Kozak & McCarthy, 1991; Harvey et al., 1996; Lundh et al., 1999) and in HTA participants experiencing high levels of state anxiety (e.g., MacLeod & Hagan, 1992; MacLeod & Rutherford, 1992; Rutherford, MacLeod & Campbell, 2004).

Despite the large number of studies that have reported selective attention for masked threat words in anxiety, there are at least three lines of evidence that question whether the effects operate completely independent of awareness. First, all studies that have reported masked threat effects have presented masked and unmasked trials in an intermixed sequence, which does not preclude the possibility that awareness of threat on the unmasked trials might prime the mechanisms responsible for processing subliminal threat information (cf. Matthews & Wells, 2000). Support for the possibility that the intermixing of masked and unmasked trials might be a necessary condition to establish masked threat bias effects comes from a report using the emotional Stroop procedure that blocked on the mode of presentation (i.e., masked and unmasked trials) and failed to find selective attention for threat during the masked trials (Kampman, Keijsers, Verbraak, Näring & Hoogduin, 2002).

The second line of evidence comes from in a recent study from our laboratory in which we reported data to suggest that the direction of attention for masked threat information changed over the course of testing (Edwards, Burt & Lipp, in press). In that study, participants tended to show masked threat interference effects in the early stages of the experiment (i.e., blocks 1 & 2) and facilitation during the latter part of the experiment (i.e., blocks 3 & 4). Because the mode of exposure in that experiment was intermixed, and participants were undoubtedly aware that they were being presented with threat words on some trials, it might therefore have been that the direction of responding to the masked threat material was affected over the course of the experiment by the presence of threat words on the unmasked exposure trials.

The third line of evidence to suggest that post-conscious awareness of threat might affect responses to masked threat material comes from a series of three experiments reported by Fox (1996). Fox employed an interference paradigm in which participants were presented with a digit in the centre of a computer screen, and their primary task was to identify the status of the digit as odd or even as quickly as possible without making mistakes. At the same time the digit was presented, a pair of threat words or a pair of neutral words was presented above and below the digit. On half the trials the word pair was presented so that participants had conscious access to the words, whereas on the other half of the trials the words were presented using a backward pattern masking procedure. Fox reasoned that the time to identify the status of the digit might be influenced by the valence of the distracting information, such that longer digit identification latencies on threat trials would indicate selective attention towards the threat information.

In Experiment 1, Fox (1996) presented the masked and unmasked trials in an intermixed sequence and the reaction time data revealed that HTA participants were significantly slower at identifying the status of the digit during masked threat word trials compared with masked neutral word trials. The data were therefore consistent with previous reports employing the emotional Stroop that have demonstrated masked threat effects in non-clinical participants (e.g., Rutherford et al., 2004; MacLeod & Rutherford, 1992). In Experiment 2, Fox blocked on the mode of exposure such that all participants received the masked block of trials before the unmasked block of trials. The results of Experiment 2 revealed a non-significant trend for HTA participants to be slowed on the digit classification task on masked threat word trials. In Experiment 3 Fox again presented the masked and unmasked trials in blocked format, but the design included the order of presentation (masked first vs. unmasked first) as a between participants factor. For the masked trials the results failed to reveal significant word type difference when participants received the masked trial block before the unmasked block. However when the unmasked block was presented first, HTA participants were significantly slowed on the number classification task during masked threat trials compared to masked neutral trials. Because the masked threat bias was only evident when participants had been presented with an intermixed sequence of masked and unmasked trials (Experiment 1), or when unmasked exposures were presented before masked exposures (Experiment 3), Fox suggested that some awareness of threat might be needed to elicit selective attention for subliminal threat material.

Despite the possibility that post-conscious awareness of threat might be needed to establish masked threat bias effects, there is at least one difficulty with Fox's procedure that requires resolving before this explanation can be accepted. In Experiment 1 and 2, Fox employed experimental procedures designed to elevate state anxiety, whereas in Experiment 3 there was no mention of a state anxiety manipulation. In non-clinical samples masked threat processing biases have typically been restricted to testing sessions involving elevated state anxiety (see e.g., Edwards et al., 2006; MacLeod & Rutherford, 1992; Rutherford et al., 2004) and therefore it is plausible that the absence of a masked threat effect in the masked exposure first condition of Fox's third experiment can be accounted for by the lack of a state anxiety manipulation. One of the aims of the present study was to investigate this possibility.

A secondary aim of the present experiment was to investigate further the lack of threat processing effects during the unmasked trials in a number of experiments (e.g., Fox, 1996; MacLeod & Rutherford, 1992). For example, although Fox interpreted the lack of unmasked threat effects for the HTA group in terms of a strategic inhibitory mechanism, it might also have been that the state anxiety manipulations reflecting a past stressor (Experiment 1) and future stressor (Experiment 2) were not sufficiently sensitive to produce threat processing biases on these trials. In a recent paper we reported unmasked threat bias effects in a sample of HTA participants who were *currently* under stress using the emotional Stroop (Edwards et al., 2006). Perhaps the differential data patterns between our study and previous experiments that have failed to report unmasked threat processing biases in non-clinical samples (e.g., Fox, 1996; MacLeod & Rutherford, 1992) might be accounted for on the basis of the immediacy of the state anxiety manipulation. In the present paper we readdress that issue.

To investigate whether post-conscious awareness of threat is necessary to produce masked threat bias effects, the present experiment employed masked and unmasked exposure trials, but blocked on the mode of exposure. Half the participants received masked exposures before unmasked exposures, whereas the other half received the opposite. The threat and neutral words employed have shown to be effective in producing attentional bias effects in previous research (Edwards et al., 2006). To control for item specific priming effects, each item was presented on just one occasion to each participant. Following previous work employing non-clinical samples (e.g., Edwards et al., 2006; MacLeod & Rutherford, 1992), participants were assigned to the HTA and LTA groups on the basis of questionnaire scores. To permit an investigation of the effects of an immediate state anxiety manipulation, threat of electric shock was employed on half the trials. To ensure that each participant performed under threat of shock and without threat of shock during the masked and unmasked exposures, the shock manipulation was varied across the 4 blocks of 40 trials.

Following the models of Mogg and Bradley (1998) and Williams et al. (1988, 1997) we predicted that HTA individuals, relative to LTA individuals, would be slower to colour name masked and unmasked threat words compared to neutral words, and this effect would be evident when performing under the threat of shock. There should be no effect of blocking on exposure mode. However, if post-conscious awareness of threat is necessary to reveal preconscious selective processing, then HTA participants, relative to LTA participants, should be slower to name the colours of masked threat words compared to neutral words, but only for those who receive unmasked exposures first. If, on the other hand, the null results obtained by Fox (1996) during masked exposures in Experiment 3 were attributable to the lack of a state anxiety manipulation, then the same pattern of colour naming data should be observed, but it would be independent of whether participants received masked or unmasked exposures first.

Method

Participants

One hundred and six undergraduate students from the University of Queensland who reported English as their first-learnt language, had normal colour vision, and normal or corrected to normal vision were invited for the first screening. Prior to participation all provided voluntary informed consent, and in return received subject credit. Because previous research had demonstrated that high levels of depression might conceal masked threat effects in anxiety (Bradley, Mogg, Millar & White, 1995), only those who scored 16 points or below on the Beck Depression Inventory – Revised (BDI-R; Beck, 1993; Beck, Rush, Shaw & Emery, 1979; Beck & Steer, 1993) participated. To reduce the effects of social desirability in differentiating the HTA and LTA groups (see Weinberger, Swartz & Davidson, 1979), only those who scored 5 or fewer socially desirable responses on the Marlowe-Crowne Social Desirability Scale-Form XI (MCSDS; Crowne & Marlowe, 1960; Strahan & Gerbasi, 1972) participated. Of the participants whose data was discarded following these screening criteria, 8 were rejected on the basis of high depression, 19 as a result of high social desirability, one exercised her right to withdraw when she was reminded about the use of electric shock, and two participants due to experimenter error. The data from one additional participant was discarded when she voluntarily indicated that she had intentionally crossed her eyes during the colour naming trials so that her performance was not hindered by the content of the words. The data from a further 11 participants were excluded due to above criterion performance in the final awareness check trials.

The final sample consisted of 64 participants aged between 17 and 46 years (M = 21.37 years). Following previous research (e.g., Edwards et al., 2006; MacLeod & Rutherford, 1992) those who scored 37 and above on the State-Trait Anxiety Inventory (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) were assigned to the HTA group (n =

32), and those who scored below 37 were assigned to the LTA (n = 32) group. The groups did not differ with respect to age, $t < 1$, or sex ratios (i.e., there were 7 males and 25 females within each group).

Materials

Word stimuli. The stimulus set employed by Edwards et al. (2006) was used. However, in the present experiment no differentiation on the basis of threat specificity was made. The 80 threat-related words were length and frequency matched with 80 non-threat, household related control items, both $F < 1$. Half the items from each word type were further divided into two, length- and frequency-matched 80-item sets (A and B; see appendix). Frequency counts were taken from the British National Corpus of approximately 89 million words (Kilgarriff, 1998). The assignment of the item sets to the masked and unmasked exposure modes, and to the threat of shock and shock safe conditions, was fully counterbalanced across participants. The mode of exposure was blocked such that half the participants received two blocks of 40 trials in the unmasked mode followed by two blocks of 40 trials in the masked exposure mode, whereas the other half received the reverse order. For half of the participants the ordering of the shock condition across the four blocks of trials was shock threat/shock safe/shock threat /shock safe, whereas for the other half it was shock safe/ shock threat/shock safe/shock threat.

Item valence was randomly intermixed during the trial blocks, with the restriction that not more than two items of the same valence occurred in succession. Colour distributions were made such that each colour was assigned to each word type an equal number of times across the first and second blocks of 80 trials, and that the threat words and their length- and frequency-matched control always appeared within the same block, and in the same colour. The presentation of the colours was randomised but governed by the restriction that the same colour did not occur on more than two successive trials. To reduce the possibility of item specific priming effects, participants were exposed to each of the 160 items on one occasion only.

A set of 200 uncategorized neutral words and 200 non-words in English between 4 and 11 characters was used for the masked threshold setting trials. To ensure that threshold levels were conservative, word stimuli were presented in lower case, whereas the non-words consisted of random consonant strings presented in uppercase. The unused stimulus sets used in the masked threshold setting trials were used for the final awareness check trials. A further set of 40 uncategorized words was developed for the practice trials, and all stimuli were presented in lettering approximately 1cm high.

Arousal Rating Questionnaire. A short, self-report, Arousal Rating Questionnaire, was used to assess participant's fearfulness, nervousness and anxiousness during the shock threat and shock safe conditions. Ratings on these dimensions have been shown to correlate with total scores on the STAI-S, and justification for including them as indices of state anxiety is reported elsewhere (Edwards et al., 2006). Participants rated their current reaction to the statement 'Right now, at this moment I feel' on the dimensions of nervous to calm, fearful to not-at-all fearful, and anxious to not-at-all anxious, using a seven-point scale with the range 3-2-1-0-1-2-3. For example, on the nervousness scale a score of 3 indicated that the participant reported feeling *very* nervous, a score of 2 *quite* nervous, and a score of 1 *slightly* nervous. The same numerical ratings held true for the calm end of the scale. A rating of 0 indicated that the participant was *neither* nervous *nor* calm.

Apparatus

Experimental hardware. The stimuli were presented by a Dell OptiPlex GX110 Pentium 3 computer running at 866 MHz using a Video Stimulus Generator video card (VSG; 2-3 issue 4a) capable of refresh rates up to 500 Hz (2 ms). The items appeared on a Hitachi Superscan 813 21-inch colour monitor with a vertical refresh rate of 200 Hz (5 ms).

A custom-built two-button response box was attached to the computer for use in the threshold setting and awareness check trials, and this box was labelled WORD (left button) and NON-WORD (right button). Participants wore a headset microphone, and colour naming latencies were detected by a voice-activated relay connected to the computer.

Experimental software. The VSG software controlled the presentation of stimuli for the threshold setting trials, practice trials, awareness check trials, and colour naming trials. The software also recorded reaction latencies and errors.

Electric stimulus. A Grass SD9 stimulator (0-90V) delivered the 200ms electric stimulus through a concentric stainless steel electrode with a 35mm diameter. Electrode-skin contact was made through a sponge soaked in saline.

Procedure

Participants were tested individually on all tasks and measures, and testing took approximately 35-45 minutes for each participant. After providing voluntary informed consent, they completed the STAI-S, STAI-T, MCSDS, and the BDI-R. Participants were assigned to the HTA and LTA groups on the basis of their STAI-T scores. After completing the inventories they undertook the exposure threshold and shock setting procedures, the practice and experimental colour naming trials, and a final series of awareness checks.

Masked exposure threshold setting. The procedure used to set the individual masking threshold was identical to that reported by Edwards et al. (2006). On each lexical decision trial, a fixation cue consisting of a row of three white crosses was presented for 1 s in the centre of the screen, the screen was blanked for 250 ms, and then either a word + pattern mask, or non-word + pattern mask, was presented in red, green, blue or yellow colouring in the location formerly occupied by the crosses. Participants began with a block of 10 trials in which 5 words and 5 non-words were presented randomly, and indicated the lexical status of the item that had preceded the mask by using a button box. When unsure they were encouraged to guess, and any participant who reported seeing all words or non-words during a block of trials was reminded of the instructions. Following each block of trials they were given feedback on their performance. The exposure duration of the target during the first block of trials was 80 ms, and following any block in which the participant made 5 or more correct decisions the exposure time of the target was systematically shortened to 60, 40, 35, 30, 25, 20, 15, 10, and 5 ms. Following any block of trials in which they made fewer than 5 correct decisions, a block of 20 trials was administered. On any block of 20 trials that the participant made 12 or more correct responses, the exposure time of the target was shortened to the next level, and a block of 10 trials was undertaken. On any block of 20 trials in which 11 or fewer correct identifications were made, the exposure duration of the target was considered to be below the participant's lexical awareness threshold. The procedure was adapted from Dagenbach, Carr and Wilhelmsen (1989).

Shock intensity setting. The shock intensity was individually set for each participant. The electrode was attached to the volar surface of the participant's right forearm, and commencing from a baseline of zero volts, the intensity of the 200 ms shocks was increased until the participant reported that the shock was 'uncomfortable, but not painful'. Once the shock intensity was set the electrode was removed.

Colour naming trials. Participants undertook four blocks of 40 colour naming trials. On each trial, a fixation cue consisting of a row of three white crosses, was presented for 1 s in the centre of the screen, the screen was blanked for 250 ms, and then either a stimulus word, or stimulus word + pattern mask, was presented in the location formerly occupied by the cue in red, blue, yellow or green lettering. Participants were instructed to ignore the meaning of the words, and to name the colour of the lettering as quickly as possible without making too many mistakes. On unmasked trials, the word remained on the screen until the software detected the participant's first vocal response, and the screen was then blanked. For the masked trials, the target word was presented for the duration of each participant’s lexical decision threshold, and at its offset, a pattern mask of the same colour replaced it. The mask remained on the screen until the software sensed the participant’s response, and the screen was then blanked. Responses were coded as correct when the participant’s first utterance correctly named the colour of the item, and incorrect if it did not (e.g., stuttering, saying the wrong colour, naming the word). Response coding initiated the next trial, and the inter-trial interval was approximately 2 s. Prior to undertaking the experimental trials, participants completed an intermixed sequence of 20 masked and 20 unmasked practice trials.

Participants received 2 blocks of shock threat and 2 blocks of shock safe trials over the 4 blocks of colour naming trials. Half of the participants within the HTA and LTA groups received the ordering of shock threat/shock safe/shock threat/shock safe, whereas the other half received the reverse ordering. Between each block of trials participants completed the Arousal Rating Questionnaire and when about to perform under the threat of shock, the measure was completed with the shock electrode attached. When participants were about to perform under the threat of shock during block 1 or block 2, they were instructed that the computer would deliver two or three shocks at random during the following block of 40 trials. Once they had indicated that they understood this instruction they completed the Arousal Rating Questionnaire. Approximately 15 s prior to the first trial in blocks 1 or 2 participants were administered one shock, and they received a second shock immediately following the final colour-naming trial in that block. When about to perform under the threat of shock in block 3 or block 4, participants were informed that the computer would again deliver up to three shocks at any time over the next block of trials. These instructions were designed to make participants believe that further shocks would be delivered, but in reality none were administered.

Awareness check trials. To verify that each participant's threshold for awareness had not changed over the course of the experiment, a series of 40 awareness checking trials were administered, and these were governed by the same parameters employed in the exposure threshold setting procedure. The data from any participant who made in excess of 23 correct lexical decisions on these trials was excluded. At the conclusion of this procedure participants were debriefed, thanked, and released.

Results

Manipulation Checks

Validity of trait anxiety status. The HTA group (*M* = 45.25; *SD* = 5.99) reported significantly higher trait anxiety than the LTA group (*M* = 29.09; *SD* = 4.31). Analyses of the other psychometric measures revealed that HTA participants also reported higher state anxiety (*M* = 38.56; *SD* = 8.67), $t(62) = 5.55$, $p < .001$, and depression (*M* = 8.59; *SD* = 3.40), $t(62) = 5.35$, $p < .001$, than their LTA counterparts (*M*s = 28.56 and 4.16; *SD*s = 5.34 and 3.23, respectively). The sample groups were matched on social desirability, $t < 1$.

Validity of state anxiety manipulation. There was no significant difference in intensity of the electric stimulus between the HTA (*M* = 36.72 V) and LTA (*M* = 37.03 V) groups, $t < 1$. To provide a single index of rated arousal on each dimension, ratings were collapsed over the two shock threat blocks and the two shock safe blocks, for the HTA and LTA groups, and these data are shown below in Table 1. To confirm the effectiveness of the threat of shock in elevating state anxiety, a series of repeated measure t-tests were preformed on each dimension of the rating data in the shock threat and shock safe conditions, for the HTA and LTA groups. The results confirmed the effectiveness of the threat of shock in elevating state anxiety in both groups, on all dimensions, all $t(31) > 5.81$, all $p < .001$.

Insert Table 1 about here

Validity of masking procedure in preventing awareness. There was no difference in the mean exposure duration of the masked words between the HTA (*M* = 23 ms) and LTA groups (*M* = 21 ms), $t < 1$, and no between group differences on the mean percentage of correct responses on the final lexical decision trials between the HTA (*M* = 19.75; *SD* = 2.59) and LTA (*M* = 19.38; *SD* = 3.02) groups, $t < 1$. The results of a *z* test showed that the mean number of correct responses from the overall sample (*M* = 19.56; *SD* = 2.80) did not differ from that expected by chance, $z = .16$, *n.s*. Taken together, these data suggest that it was unlikely participants were aware of the lexical status of the items in the masked condition.

Data Cleaning

The data were reduced in four stages prior to analysis. Trials involving: (a) microphone failures (0.46% of trials), (b) colour naming errors (2.15%), (c) response times less than 300 ms or greater than 3000 ms (0.27% of trials), and (d) response latencies more than two standard deviations from each participant's cell mean (4.48% of trials) were removed.

Colour Naming Latency Data

Each participant's mean response latency for the colour naming trials was extracted for each word type, exposure mode, and presentation order, in the shock threat and shock safe conditions, and these data are shown in Table 2. A 2 X 2 X 2 X 2 X 2 split-plot factorial ANOVA was carried out on the colour naming latency data. The within subjects factors were Valence (threat words vs. non-threat words), Exposure Mode (masked vs. unmasked), and Shock Condition (shock threat vs. shock safe), whereas the between subjects factors were Trait Anxiety (high vs. low) and Presentation Order (masked block first vs. unmasked block first).

Insert Table 2 about here

The ANOVA produced a highly significant main effect for Exposure Mode, $F(1, 60) = 187.02$, $MSE = 1766.53$, $p < .001$, $\eta^2 = .76$, and a marginally significant main effect for Shock Condition, $F(1, 60) = 3.99$, $MSE = 1093.47$, $p = .052$, $\eta^2 = .06$. Response latencies on unmasked trials ($M = 603$ ms) were slower than those on masked trials ($M = 552$ ms), and reaction times were slower for trials performed under threat of shock ($M = 581$ ms) than for those performed in the shock safe condition ($M = 575$ ms). The results also revealed a significant 2-way interaction involving Presentation Order X Exposure Mode, $F(1, 60) = 13.98$, $p < .05$, $\eta^2 = .19$. Tests for the simple effects of presentation order suggested that whereas response latencies to unmasked presentations were not affected by whether participants received unmasked ($M = 603$ ms) or masked ($M = 604$ ms) trials first, $t < 1$, participants were faster to respond to masked trials when they received masked trials first ($M = 539$ ms) than when they received unmasked trials first ($M = 566$ ms), $t(62) = 2.03$, $p = .046$.

The ANOVA also yielded reliable Trait Anxiety X Valence X Exposure Mode, $F(1, 60) = 5.01$, $MSE = 344.65$, $p = .029$, $\eta^2 =.08$, and Trait Anxiety X Valence X Presentation Order, $F(1, 60) = 5.88$, $MSE = 287.60$, $p = .018$, $\eta^2 = .09$, interactions. These interactions indicated that the HTA and LTA groups showed different patterns of colour naming responses to the threat and non-threat words, and that these patterns were separately influenced by the mode of presentation, and by whether participants were exposed to masked or unmasked trials first. To decompose the nature of each interaction, two indices of processing bias were calculated. First, an index of threat processing bias collapsed over Presentation Order and Shock Condition was extracted for each participant in each exposure mode by subtracting the mean colour naming latencies for the non-threat words from the mean colour naming latencies from the threat words. Second, the same index of threat processing bias collapsed over Exposure Mode and Shock Condition was calculated for each participant in each presentation order. Positive scores reflect interference in colour naming whereas negative scores reflected facilitation. Separate analyses for Presentation Order and Exposure Mode were then performed on the relevant threat processing indices for the HTA and LTA groups.

Exposure mode. The pattern of processing bias for the HTA and LTA groups in each exposure mode is shown below in Figure 1. Follow-up tests for the simple effects of Exposure Mode revealed that, on masked trials, there was no difference in threat processing bias between the LTA (M = 5 ms) and HTA (M = 0 ms) groups, $t(62) = 1.22$, $p = .228$, *n.s.*, however, on unmasked trials, group differences in threat processing bias were significant $t(62) = 2.01$, $p = .045$. On these trials, the HTA participants tended towards interference (M = 4 ms), whereas their LTA counterparts tended to show the opposite effect (M = -5 ms). The threat processing bias was not, however, significantly different from zero for either group in either exposure mode, all $t < 1.55$, $p > .132$, *n.s*.

Insert Figure 1 about here

Presentation order. Figure 2 illustrates the pattern of processing bias for the HTA and LTA groups as a function of whether they received masked or unmasked trials first. As the figure shows, there was no difference in the processing of threat material between the HTA (M = 1 ms) and LTA (M = 6 ms) groups when exposed to masked presentations first, $t(30) = 1.18$, $p = .247$, *n.s.* However, when participants were exposed to unmasked presentations first, group differences in threat processing bias were significant, $t(30) = 2.32$, $p = .027$. As before, HTA participants tended towards interference (M = 3 ms) whereas LTA participants tended to show the opposite pattern (M = -6 ms). The threat processing bias did not differ significantly from zero for either group in either presentation order, all $t < 1.55$, *p*s > .125, *n.s*.

Insert Figure 2 about here

Discussion

The present experiment was designed to assess a number of predictions made by the models of Mogg and Bradley (1998) and Williams et al., (1988, 1997), and to determine whether post-conscious awareness of threat is needed to establish selective attention for subliminal threat information. The models of Mogg and Bradley and Williams et al. predict that HTA individuals, relative to LTA individuals, are slower to colour name unmasked and masked threat words compared to neutral words and that this effect would be most pronounced when performing under high stress conditions. Both theoretical positions also predict that there should be no effect of blocking on performance. However, if post-conscious awareness of threat is necessary to produce selective attention for threat effects, then during the masked exposures, HTA participants, relative to LTA participants, should have been slower to name the colours of threat words compared to neutral words, and this effect should only have been evident for those who received unmasked exposures before masked exposures. The data provided strong support for the notion that post-conscious awareness of threat is necessary to produce threat bias effects in anxiety.

The Trait Anxiety X Valence X Exposure Mode interaction indicated that HTA participants were slower to name the colour of the unmasked stimuli on threat word trials relative to neutral word trials, compared to the LTA group, with no between group differences being apparent for the masked trials. These data are consistent with results reported by Kampman et al. (2002), who blocked on the mode of exposure and reported a similar pattern of data to those reported here. When considered together, it would seem that blocking on the mode of exposure has little effect on illuminating selective attention for unmasked threat, but that this procedure might not be optimal for revealing masked threat effects. The data for the unmasked trials therefore add to a growing number of reports suggesting that non-clinical anxiety is characterised by a bias to attend to threat information (e.g., Edwards et al., 2006; Miller & Patrick, 2000). As participants were instructed to ignore the content of the words and to name the colours as quickly as possible, the data suggest that this bias proceeds without volition within the attentional system. As such, the data from the unmasked trials are in line with the models of Mogg and Bradley (1998) and Williams et al. (1988, 1997).

Counter to predictions made by the models of Mogg and Bradley (1998) and Williams et al., (1988, 1997) the results of the current study provided evidence that selective attention for threat words is moderated be strategic factors reliant on post-conscious awareness of threat. As evidenced by the Trait Anxiety X Valence X Presentation Order interaction, the HTA and LTA groups showed an equivalent pattern of colour naming the threat and neutral words when they were exposed to masked trials before the unmasked trials. However, when participants received unmasked trials first, HTA participants displayed a larger threat bias than did LTA participants. These results are conceptually similar to those reported by Fox (1996; Experiment 3) who employed an experimental design equivalent to the one used here. It would appear that anxious individuals do selectively process subliminal threat information, but only under conditions in which unmasked and masked trials are intermixed (e.g., Fox, 1996, Experiment 1; MacLeod & Hagan, 1992; MacLeod & Rutherford, 1992; Rutherford et al., 2004), or when unmasked trials precede the masked trials (Fox, 1996, Experiment 3; current study). When the data from Fox and the present study are considered together, it would seem that, at least for verbal material, post-conscious processes might activate a threat detection mechanism that lowers the threshold for detecting subliminal threat material on subsequent trials.

The fact that Exposure Mode did not further modify the Trait Anxiety X Valence X Presentation Order interaction suggests that a similar pattern of selective attention to that observed for the masked trials operated for the unmasked trails. When masked trials were presented before the unmasked trials there was no difference in response latency between HTA and LTA participants, however, HTA participants who were presented with unmasked trials first demonstrated a different pattern of responses to their LTA counterparts. Although the data for the unmasked trials are difficult to interpret, they are conceptually similar to those from a recent study in our laboratory (Edwards et al., in press). In our earlier experiment, HTA participants tended to show unmasked threat interference effects early in the testing session but not in the latter stages of testing, whereas in the present experiment HTA participants showed a threat bias effect for unmasked material when they received unmasked trials first (i.e., early in the experiment), but not following the masked trials (i.e., later in the experiment). The data reported here, coupled with that from our previous experiment (Edwards et al., in press), therefore suggest that, under some conditions, unmasked threat bias effects might be restricted to the early stages of testing. Although these effects tend to follow the predictions specified by the models of Mogg and Bradley (1998) and Williams et al. (1988, 1997), they do not operate consistently because they have shown to be systematically affected by procedural factors such as ordering of the state anxiety manipulation (Edwards et al., in press), blocking on the mode of exposure (current study), and/or the passage of time. If attentional biases for threat were truly automatic they should operate consistently across time, and irrespective of priming effects.

The fact that shock condition did not affect responses to the threat words suggests that selective threat effects might operate independently of state anxiety status, which runs counter to predictions made by the models of Mogg and Bradley (1998) and Williams et al. (1988, 1997). One interpretation of these data is that threat bias effects do not rely on elevated levels of state anxiety. This explanation seems unlikely, however, given that the threat of shock has shown to modify patterns of vigilance for threat in previous work (e.g., Edwards et al., 2006, in press; Miller & Patrick, 2000), and because there have been a number of reports to establish that selective attention for masked (e.g., Edwards et al., 2006; Rutherford et al., 2004; MacLeod & Rutherford, 1992; Mogg et al., 1993) and unmasked (e.g., Edwards et al., 2006; Miller & Patrick, 2000) threat material is restricted to periods of high state anxiety. Although the exact reasons for the difference between the present experiment and previous reports are unclear, examination of procedural differences between experiments leads to possible explanations for these inconsistencies.

One notable difference between the present study and previous reports demonstrating that selective threat effects are restricted to periods of high state anxiety is that in the present experiment the masked and unmasked items were presented in a blocked format, whereas in these earlier experiments the mode of exposure was intermixed (e.g., MacLeod & Rutherford, 1992; Rutherford et al., 2004). Because of the blocking procedure, during the unmasked exposures participants would have been aware that they were being presented with threatening words every second trial, on average. The ratio of threat to non-threat items in the present experiment therefore differs from that in studies that have intermixed masked and unmasked trials in which participants would have been aware of the presence of threat words once in every four trials, on average (e.g., MacLeod & Rutherford, 1992). It is therefore possible that the more frequent awareness of threatening information might have acted as a mood induction procedure that produced elevated levels of state anxiety in participants. If this explanation were accepted, and if selective attention for threat words were reliant on elevated state anxiety as has been reported in the literature (e.g., Edwards et al., 2006; Rutherford et al., 2004; MacLeod & Rutherford, 1992; Mogg et al., 1993), then threat bias effects would be apparent irrespective of the threat of shock, which seemed to be the case. It should be noted, however, that although this explanation might account for the data on the masked trials, it is unlikely to account for the lack of influence of state anxiety during the unmasked exposures because Fox (1996, Experiment 3) employed the same blocking procedure as used here and failed to find attention for threat during the unmasked exposures in her study.

An alternative explanation for why threat of shock did not modify selective attention in the present experiment might be based on the number of alternations between the shock conditions. In experiments that have reported selective threat effects to be reliant on elevated state anxiety, participants were alternated through the high and low state anxiety condition once (e.g., Rutherford et al., 2004; MacLeod & Rutherford, 1992), whereas in the present experiment they were alternated through these conditions twice. In addition, in these earlier experiments the high and low state anxiety conditions were conducted several weeks apart (i.e., testing took place early in semester and again in temporal proximity to end of semester examinations), whereas in the present study this manipulation was applied within a single testing session. It is therefore possible that alternating the shock threat and shock safe condition on a block-by-block basis within a single 45 minute testing session might have produced carryover effects from the high to low state anxiety conditions, which in turn resulted in higher state anxiety over the course of the experiment. It should be noted, however, that although this explanation seems plausible, it is not consistent with the arousal rating data in which participants reported higher levels of state anxiety when under the threat of shock, compared to when they performed without the threat of shock. Nonetheless, it is also possible that participants were aware of the experimental demands, and reported levels of anxiety that were consistent with the experimental manipulations.

If it were accepted that state anxiety levels were relatively high throughout the course of testing in the present study, then differences in the nature of the stressor between the present experiment and that employed by Fox (1996, Experiment 1) might explain the differential patterns of results for the unmasked trials. In the current experiment, we employed threat of shock, which was designed to reflect an immediate stressor, whereas Fox (Experiment 1) employed a stressor that represented a past event (i.e., participants were presented with photographs of disturbing scenes prior to the task) and a future oriented stressor in Experiment 2 (i.e., impending exams). We recently reported an unmasked threat bias effect in a sample of HTA participants who were *currently* under stress when performing the emotional Stroop (Edwards et al., 2006), and suggested that the differential patterns of data between our study and previous experiments that have failed to report unmasked threat biases in non-clinical samples (e.g., Fox, 1996; MacLeod & Rutherford, 1992) might be accounted for by the immediacy of the state anxiety manipulation. On the basis of previous experiments that have reported selective attention for unmasked threat material in the high state anxiety condition alone (e.g., Edwards et al., 2006; Miller & Patrick, 2000), it would seem that the differential nature of the state anxiety manipulation would offer the most parsimonious explanation for why unmasked threat effect were evident in the present study.

One possible limitation of the present experiment was that we employed the emotional Stroop paradigm to provide an index of selective processing. There have been several studies describing the disadvantages of using this protocol, with the greatest drawbacks being the task's inability to differentiate attentional vigilance from avoidance (see e.g., Thorpe & Salkovskis, 1997), and attentional engagement from disengagement (e.g., Fox, Russo & Dutton, 2002). Because of these limitations there have been strong arguments for the use of the dot-probe task over the emotional Stroop. Although there are some advantages in using dot-probe procedures to provide a direct measure of selective spatial attention, the task seems unable to address whether selective attention for threat operates automatically, at least in the sense that it occurs without volition. This difficulty arises because the probe-task does not rely on competition for attentional resources, and as such, it is plausible that participants might simply *choose* to attend to one stimulus type (e.g., threat words) over another (control words), which in turn would facilitate responses to probes replacing items of that valence. This argument seems particularly relevant during unmasked exposure trials in which participants have clear access to the semantic content of the items and there is a delay between the presentation of the item and the onset of the probe. The emotional Stroop, on the other hand, requires competition for attentional resources between the to-be-ignored information (the semantic content of the item) and the to-be-attended information (the colour of the item). Differential reaction times to items of a particular valence (e.g., threat words) over others (e.g., control words) can be inferred as occurring without volition because participants are explicitly instructed to ignore the semantic nature of the words. The emotional Stroop would therefore seem more suited than the dot-probe task to address whether processing bias effects occur without volition within the attentional system.

It is worth noting that the present study employed a sample chosen explicitly on the basis of low depression scores. Anxiety and depression are known to strongly co-vary and because previous research had indicated that depression might not be associated with a bias to selectively process briefly presented negative material (see e.g., Bradley et al., 1995) we considered this exclusion criteria necessary to permit a sensitive test of preattentive effects in genuinely LTA and HTA participants by limiting the potentially contaminating effects of depression. As such, the present HTA sample is unusual with respect to how anxiety usually manifests and some caution may be warranted in generalising the results to individuals reporting high levels of depression. A final possible limitation of the present work concerns the use of a median-split on the Trait Anxiety variable and ANOVA as the data analytic technique. Dichotomisation of the anxiety variable has the potential to remove variance from the model, potentially making significant effects in the data appear non-significant. In defence of our position to employ the current approach, we considered dichotomisation and the use of ANOVA as an extremely conservative test of the data. The effects reported in the manuscript are therefore likely to reflect a stringent evaluation of the theories under investigation.

In summary, the data from the present study pose problems for the models of Mogg and Bradley (1998) and Williams et al. (1988, 1997). These frameworks suggest that anxiety is characterised by automatic threat processing biases that operate without volition and without awareness. However, the data reported here, coupled with those reported by Fox (1996), support the notion that post-conscious awareness of threat is needed to prime the mechanisms responsible for the processing of subliminal threat material. In addition, the data also suggest that unmasked threat biases do not operate in a consistent manner over the course of testing.

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Table 1.

Means and Standard Deviations of HTA and LTA Participants' Responses on Arousal Rating Questionnaire Dimensions under Shock Threat and Shock Safe Conditions

	High Trait Anxious				Low Trait Anxious			
	Shock Safe		Shock Threat		Shock Safe		Shock Threat	
Variable	M	SD	M	SD	M	SD	M	SD
Calm- Nervous	-0.64	1.34	1.09	1.17	-1.03	1.34	0.61	1.50
Not Fearful- Fearful	-1.09	1.23	0.44	1.26	-1.61	1.24	0.02	1.72
Not Anxious-Anxious	-0.59	1.52	1.31	1.31	-1.06	1.40	0.72	1.53

Note: Positive scores denote greater nervousness, fearfulness and anxiety whereas negative scores denote the opposite.

Table 2.

Means and Standard Deviations of Colour-Naming Latency Data in Milliseconds for High Trait Anxious and Low Trait Anxious Participants in Each Experimental Condition

	High Trait Anxious				Low Trait Anxious			
	Shock Safe		Shock Threat		Shock Safe		Shock Threat	
Variable	M	SD	M	SD	M	SD	M	SD
Unmasked First								
Masked Trials								
Threat Words	545	66	556	47	577	48	588	54
Control Words	550	57	549	46	576	50	590	42
Unmasked Trials								
Threat Words	579	67	604	72	611	58	613	53
Control Words	581	72	591	75	627	48	620	43
Masked First								
Masked Trials								
Threat Words	531	57	538	58	552	65	548	64
Control Words	533	55	539	59	544	54	534	53
Unmasked Trials								
Threat Words	598	58	611	56	609	58	604	54
Control Words	596	56	608	47	599	47	610	62

List of Figures

Fig 1

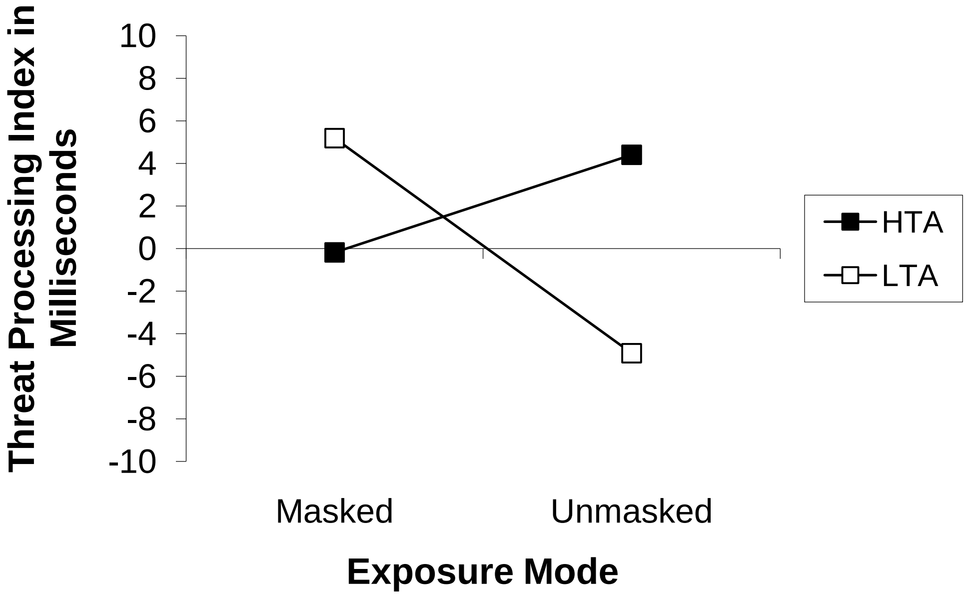
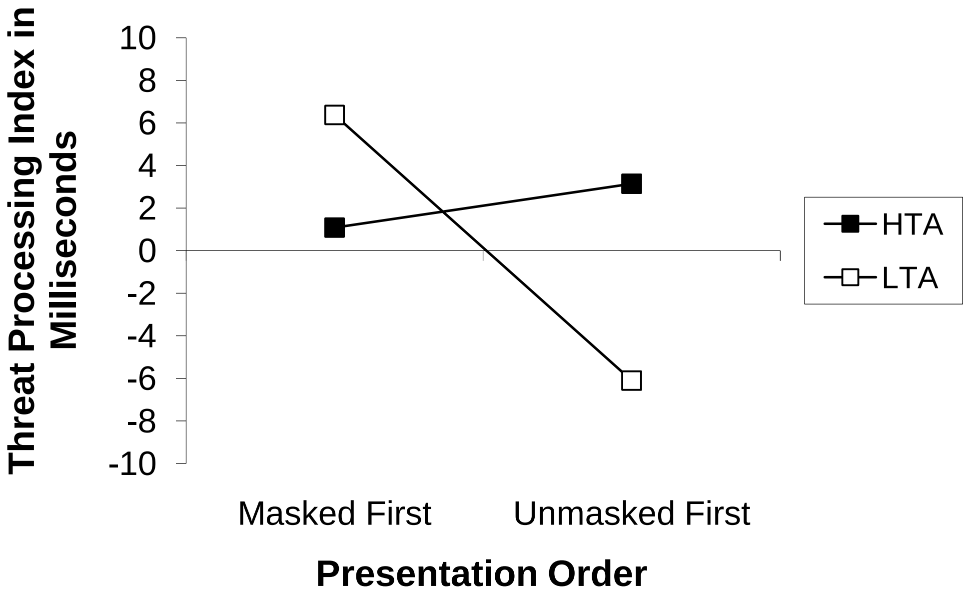

Threat Processing Index in Milliseconds
10
8
6
4
2
0
-2
-4
-6
-8
-10
Masked
Unmasked
Exposure Mode
HTA
LTA

Fig 2


Threat Processing Index in Milliseconds
10
8
6
4
2
0
-2
-4
-6
-8
-10
Masked First
Unmasked First
Presentation Order
HTA
LTA

Appendix

Stimulus Words with Frequencies Per Million X 89 in Parentheses

Set A		Set B	
Threat Words	Matched Controls	Threat Words	Matched Controls
Burn (1559)	Fence (1502)	Burnt (1100)	Cups (1173)
Cable (1863)	Bench (1869)	Charge (9528)	Glass (9369)
Charred (185)	Ottoman (328)	Circuit (2552)	Ceiling (2184)
Current (13599)	Computer (12964)	Danger (5709)	Coffee (5724)
Electrical (2136)	Newspapers (3332)	Electricity (3476)	Comfortable (3718)
Electrify (14)	Bedspread (62)	Electrocute (0)	Furnishings (404)
Electrode (122)	Appliance (157)	Fear (8689)	Step (8313)
Frightened (2408)	Photograph (2462)	Generator (401)	Cupboards (442)
Hazard (829)	Illness (3118)	Hurt (4145)	Desk (4209)
Intense (2303)	Crystal (2062)	Lethal (626)	Fridge (652)
Lightening (480)	Typewriter (416)	Pain (6928)	Chair (6969)
Painful (1823)	Washing (2070)	Polarity (116)	Crockery (121)
Scar (411)	Taps (434)	Shocking (534)	Dwelling (538)
Shocks (346)	Saucer (308)	Singed (45)	Laundry (52)
Sparks (418)	Sponge (419)	Spasm (184)	Eaves (183)
Sting (552)	Towel (794)	Stinging (504)	Cushion (435)
Voltage (837)	Basement (792)	Volt (97)	Hinge (194)
Wires (656)	Bowls (639)	Watts (450)	Apron (453)
Wound (2062)	Cloth (1823)	Wiring (364)	Trough (305)
Zapped (20)	Soaped (15)	Unpleasant (1255)	Apartment (1272)
Amputate (11)	Latticework (13)	Abuse (3389)	Sugar (3365)
Coffin (1317)	Carpet (2088)	Cancer (4023)	Bottle (3634)
Deceit (205)	Blinds (269)	Dead (11643)	Wall (11180)
Diseased (178)	Linoleum (117)	Disgraced (178)	Brickwork (266)
Dumb (667)	Rack (696)	Embarrass (195)	Wardrobes (113)
Evil (2745)	Beds (2038)	Fail (3238)	Bath (3318)
Grief (1315)	Suite (1322)	Hate (2390)	Keys (2095)
Hateful (105)	Archway (190)	Humiliate (112)	Fireplace (689)
Illness (3118)	Bedroom (3674)	Inadequate (2263)	Furniture (3204)
Incompetent (350)	Mantelpiece (298)	Infection (2654)	Doorway (1619)
Kill (4375)	Iron (4375)	Lacking (1479)	Blanket (1061)
Lonely (1696)	Garage (1603)	Massacre (621)	Spacious (653)
Murder (5781)	Cabinet (6347)	Mutilation (92)	Dishwasher (170)
Pathetic (625)	Lavatory (549)	Peril (289)	Settee (244)
Punishment (2211)	Decoration (914)	Sadness (754)	Shelves (1115)
Satan (375)	Stair (339)	Snake (718)	Spoon (706)
Stupid (2439)	Sheets (2127)	Starve (247)	Opener (263)
Tumour (879)	Bucket (848)	Torture (863)	Curtain (1297)
Violence (5350)	Pictures (5057)	Ugly (1252)	Hook (1303)
Worry (4516)	Doors (4383)	Spider (1272)	Pillow (666)