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Blind to Threat:

The Presence of Temporary Goals Prevents Attention to Imminent Threat Already at Early Stages of Attention Allocation

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Author Note

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Abstract

Human attention is biased by several motivational factors. For instance, threat attracts attention. People also preferentially pay attention to goal-relevant stimuli even when they are not emotional. How is attention allocated when individuals encounter multiple stimuli with different motivational salience that compete for limited attentional resources? Recent evidence suggests that neutral but goal-relevant stimuli are prioritized over threat when they are simultaneously presented. However, the role of strategic attentional processes in this bias is unknown. To address this issue, we conducted two studies that presented goal-relevant and fear-conditioned threatening stimuli in a dot probe paradigm at early (30 ms) and later stages (250 ms) of attentional processing. Across both studies, attention was allocated to goal-relevant stimuli over threatening stimuli at both presentation times. However, attentional bias to goal-relevant stimuli was larger at later stages of attentional processing. Further, attention to goals over threat was reduced in people high in trait anxiety in the main study. These findings corroborate the conclusion that temporary goals determine attention allocation in a relatively automatic manner, but the influence of goals is stronger at later stages of attention allocation.

Key words: attentional bias, goal pursuit, motivation, threat, negativity bias

Introduction

People's daily surroundings contain vast quantities of complex information. Attention helps to selectively filter more important aspects of the environment while ignoring unnecessary information (e.g., Feldmann-Wüstefeld & Vogel, 2019). Motivation is a major determinant of attention allocation with stimuli that represent motives, needs, and goals preferentially attracting attention (Cunningham & Brosch, 2012; Lang et al., 1997). For instance, biologically significant information such as babies (Brosch et al., 2008) or threatening events (Kappenman et al., 2015) bias attention. Likewise, temporary goals impact attention as well. As an example, hunger and thirst cause attention to food and beverages (Mogg et al., 2008). In the present study, we ask how attention is allocated when threatening stimuli and neutral stimuli relevant to a temporary goal compete for attentional priority and whether attention allocation differs in earlier versus later stages of attentional processes.

Existing theories have emphasized the importance of detecting threatening stimuli because this might facilitate an appropriate response to ensure survival (i.e., fight or flight; Lang et al., 1997). In line with this reasoning, people attend to threatening over neutral stimuli (see Yiend, 2010, or Abado, 2021, for overviews). For instance, unpleasant pictures attract eye saccades to a greater extent than pleasant or neutral pictures (McSorley & Van Reekum, 2013). Likewise, threatening stimuli that are associated with imminent threats such as loud noises cause slower disengagement of eye movements than neutral stimuli (Mulckhuyse et al., 2013;

Mulckhuyse & Dalmaijer, 2016; see also Koster et al., 2004; Notebaert et al., 2011). Similarly, pictures of dangerous animals (e.g., snakes and spiders, Öhman et al., 2001), or guns and syringes (Brosch & Sharma, 2005) bias attention. Further, pictures of angry faces but not of their mere physical features (Schubö et al., 2006; West et al., 2009; but see Schettino et al., 2011) also attract attention. It is often assumed that this bias evolved in the evolution of the human species and is consequently hard-wired and unconditional by now (e.g., Bradley, 2009). Models of emotional attention therefore emphasize that emotional events attract attention in a bottom-up driven and automatic manner (see Yiend, 2010, for an overview). However, failures to find automatic attentional bias to threat, especially in non-anxious samples, cast doubt on this notion (see Abado et al., 2020; Pessoa & Adolphs, 2010; Vuilleumier & Huang, 2009, for overviews of this debate).

Threat is not the only motivational factor which affects attention. Models of goal pursuit (Cole & Balcetis, 2021; Moskowitz, 2002; Rothermund et al., 2008) argue that temporary goals unrelated to threat also determine attention allocation. During goal pursuit, goal-relevant information is activated in working memory, causing neurons with a receptive field to be tuned towards goal-relevant information (de Bourbon-Teles et al., 2014; Yantis, 2000). Consequently, goal-relevant stimuli attract attention once a goal is activated (see Büsel et al., 2020; Vogt et al., 2020, for overviews). For instance, inducing a temporary goal to be more egalitarian by asking participants to recall times where they had not been fair to others led to a greater amount of attention to words relating to egalitarianism (Moskowitz, 2002). Similar findings have also been found for participants with a goal to win points, drink, and eat (Aarts et al., 2001; Mogg et al., 1998; Vogt et al., 2010). Altogether, these findings illustrate how attention is preferentially allocated to stimuli that support achievement of a goal.

Temporary goals might also play a role in attentional bias to threat (e.g., Brown et al., 2020; Rothermund et al., 2008). For instance, chronic or temporary goals related to threat such as to monitor the environment for potential dangers might underlie attentional bias to threat (e.g., Brown et al., 2020; Vogt et al., 2017; Wells & Matthews, 1996). Specifically, whilst several studies demonstrate that threatening stimuli attract attention, threatening stimuli in these studies are often also relevant to the goal of the attention task (Mulckhuyse & Dalmaijer, 2016) such as when participants must search for threatening stimuli in visual search tasks (e.g., Öhman et al. , 2001). Indeed, when participants were told to look for either a happy or an angry face within a screen of faces, participants were quicker to find an angry face but only when they had to look for this face (Hahn & Gronlund, 2007; see also Schubö et al., 2006). Conversely, asking participants to attend to threat-irrelevant features of angry faces such as the color of the eyes led to inattention to angry faces (Van Dillen et al., 2011), suggesting that attention bias to threat is modulated by perceiver’s goals, and therefore may not be a universal phenomenon as initially considered.

In line with these considerations, stimuli relevant to temporary goals dominate attention allocation when threatening and neutral but goal-relevant stimuli compete against each other. For instance, one experiment used fear conditioning to associate a colored rectangle with an aversive noise (Vogt et al., 2013). Participants then completed alternating trials of a dot probe task and a goal task that made another colored stimulus relevant to a temporary goal of winning tokens in the goal task. Participants displayed an attentional bias towards goal stimuli in trials containing both the goal stimulus and the threatening stimulus in the dot probe task, suggesting that goals can override attention to threat. This effect has been replicated using different stimuli and in other laboratories (e.g., Liu et al., 2020).

In the present paper, we aim to extend this work by testing the automaticity of this effect, that is, by testing how attention is allocated when stimuli are presented for a very short time which will allow us to tap into early attentional processes. Theoretical accounts suggest that goals attract attention automatically (Moskowitz, 2002). Indeed, attention to goal-relevant stimuli has also been shown for early attentional processes (Ansorge et al., 2009) but not in the presence of threat. For instance, in the studies described above, the presentation time of the stimuli in the dot probe task (i.e., 250 ms or longer) was not short enough to exclude the role of top-down attentional processes (Luck & Vecera, 2002). Therefore, it remains unclear as to whether goal-relevant stimuli are automatically prioritized over threatening stimuli in the early stage of attentional processes. Importantly, some theories argue for an early or preconscious processing of threatening stimuli (Le Doux, 1994; but see Pessoa & Adolphs, 2010; or Abado et al., 2020). Indeed, the processing of threat happens in the early stages of attention allocation, leading to an increased attentional bias during these periods (Gupta et al., 2019; Liu et al., 2020). Therefore, shortening the presentation time of stimuli within the dot probe task will inform us whether goals or threatening stimuli dominate attention allocation at the early stages of attention allocation.

Related to this issue, we will also account for the effect of trait anxiety on attentional bias to threatening stimuli and goals. High levels of anxiety increase attentional bias towards threatening stimuli (Bar-Haim et al., 2007), even when these threatening stimuli are task-irrelevant (Okon-Singer, 2018). We therefore examined how participants' level of anxiety as measured with the State Trait Anxiety Inventory-T (STAI-T; Spielberger et al., 1983) interacts with our attention measures. This will allow us to test whether anxious people will not attend to goals at all because their attentional system prioritizes threatening information or whether they only prioritize threat or non-threatening stimuli such as goals when they have strategic control over the allocation of attention at the longer presentation time (Abado et al., 2020; Wells & Matthews, 1996; Yiend, 2010).

Present Studies

We conducted two experiments to investigate attention to threat and goals at different stages of attentional processing. The two experiments were identical except for minor improvements to the design and a larger sample size in the second experiment than the pilot experiment. As done in previous studies (Vogt et al., 2010, 2013, 2017), participants' goals were manipulated by a simple goal task; during the goal task, participants saw various stimuli and were required to respond with a key press only when they saw one specific stimulus (which served as the goal stimulus). The goal task was also used to introduce a threatening stimulus. To this end, one stimulus (which was different from the goal stimulus) was followed by an aversive white noise from time to time; this stimulus served as the threatening stimulus in the study.

To measure visual attention to threatening, goal and control (i.e., a neutral stimulus irrelevant to the goal) stimuli, the studies also asked participants to complete a dot probe task (MacLeod et al., 1986) in addition to the goal task. Trials of the two tasks alternated. During the dot probe task, participants simultaneously viewed two cue stimuli and then indicated the location of a visual probe subsequently presented in the location of one of the cue stimuli. If participants selectively attend to one cue stimulus over another, they will be quicker to respond to probes following this stimulus and slower to respond to probes following the other stimulus. We used all three combinations of stimuli for this task (Goal vs. Control, Threat vs. Control, Goal vs. Threat). We presented cue stimuli for 250 ms in half of the trials (cf. Vogt et al., 2013) and for 30 ms (cf. Trawalter et al., 2008; see also Ansorge et al., 2009) in the rest of the trials. Importantly, the shorter presentation time will prevent strategic control of attention allocation (Ansorge et al., 2009; Luck & Vecera, 2002); thus, comparing performance across the short (30 ms) vs. long (250 ms) presentation conditions allows us to address the role of strategic control in the effects of goal on attention allocation.

Hypotheses

The hypotheses in our studies are as follows. First, we expect an attentional bias towards goal-relevant stimuli when presented together with a threatening stimulus in trials where the cued stimuli are presented for a long duration as done in previous studies (e.g., Vogt et al., 2013) as this presentation time allows at least some level of strategic control over attention allocation (Luck & Vecera, 2002). When the presentation duration is short, we do not have a prediction about whether participants preferentially pay attention to goals or threat when they are shown simultaneously and compete for attentional resources. Importantly, however, attention towards goals would support relevant theoretical accounts of attention to goals being automatic (e.g., Moskowitz, 2002; Pessoa & Adolphs, 2010; Vogt et al., 2017) whereas attention to threat would support dominant theories on attention to threat that suggest an even stronger early bias to threat (e.g., Vuilleumier & Huang, 2009, or Yiend, 2010, for overviews). Finally, we expect an attentional bias towards threat in the presence of control stimuli irrespective of presentation duration. Likewise, we expect an attentional bias to goals when goal-relevant stimuli are presented with control stimuli both in the short and long presentation conditions. Further, we will test the effect of trait anxiety to understand whether anxiety causes attention to threat at the different processing stages, for instance, because threat is always prioritized or whether anxiety causes attention to goals (or threat) only when anxious observers have strategic control over the allocation of attention at the longer presentation time.

Pilot study

Method

Participants and Design

Thirty participants from the University of Reading, United Kingdom, were recruited for this study. The average State Trait Anxiety Inventory (STAI-T; Spielberger et al., 1983) was 49.86 (*SD* = 11.36) suggesting subclinical to clinical levels of anxiety. Participants received course credits after completion of the study.

The study involved a 3 (Trial Type: goal vs CS-, CS+ vs CS-, CS+ vs goal) x 2 (Congruency: congruent, incongruent) x 2 (Timing: 30 ms, 250 ms) design. A G*Power sample size calculation based on the effect size of d_z = 0.83 (threat versus goal comparison, Experiment 3, Vogt et al., 2013), at an alpha of 0.05 and power of 0.80 gave a required minimum sample size of 18. We aimed to go beyond this size because we added the manipulation of presentation time. We recruited as many participants as we could within the available time frame for data collection. Our final sample size (*N* = 30) gives us 80% power to detect a medium-sized effect (Cohen's *d* = .53) and 95% power to detect a medium-to-large sized effect (Cohen's *d* = .68) for the possible interaction between presentation time and congruency in the threat versus goal condition. Based on a summary-statistics approach (Murayama et al., 2020), this sample size also gives us 80% power to detect a large-sized effect of trait anxiety on the attentional measures (r = .49).

All participants had normal or corrected-to-normal vision and were naive as to the purpose of the experiment. The study was approved to be in line with the guidelines of the University of Reading Research Ethics Committee.

Apparatus and Materials

Dot Probe Task. We based the design of the tasks on Vogt et al. (2013), see also Figure 1. During a trial of the dot probe task, participants first saw a fixation cross (5 mm x 5 mm) in the middle of the screen, with a white rectangle (60 mm x 45 mm) above and below the fixation cross. After 500 ms, these white rectangles were replaced by either a combination of (i) the conditioned threatening stimulus (CS+) and the control stimulus (CS-), (ii) CS+ and goal stimulus, or (iii) CS- and goal stimulus. The CS-, CS+ and goal stimulus were randomly chosen from three colored (purple, yellow, and blue) rectangles (60 mm x 45 mm). The HTML/HEX codes for these colors are: #ffff00 (yellow), #00a2e8 (blue), #a349a4 (purple). After a period of either 30 ms or 250 ms, these rectangles turned white again, and a black square (i.e., the probe) appeared in the middle of the either the top or the bottom rectangle. Participants were required to press either the “4” (top rectangle) or the “5” (bottom rectangle) key with their index and middle fingers of their right hand in accordance with which rectangle the black square appeared in as quickly and accurately as they could. If participants answered incorrectly (or did not respond within 2000 ms), the word “error” appeared for 200 ms. After an inter-trial interval of 700 ms, a trial of the goal task began.

Goal Task. During a trial of the goal task, participants first saw a fixation cross in the middle of the screen for 500 ms. Hereafter, the fixation cross would be replaced by the CS-, CS+, the goal stimulus, or a filler stimulus (all 60 mm x 45 mm) for 250 ms. Fourteen additional colored stimuli were used as filler stimuli to prevent habituation to the threatening (CS+) stimulus. Hereafter, the stimulus was replaced by a white rectangle and a red question mark in the middle of the rectangle. Participants were instructed to press the space bar with their left hand after the presentation of the goal stimulus and the question mark. Importantly, an aversive white noise followed the CS+ on 50% of the trials in this task. The noise lasted 460 ms and was presented at 75 dBA. After an inter-trial interval of 1000 ms, the next trial of the dot probe task began.

Procedure

After completing a consent form, participants were seated in a testing cubicle ca. 60 cm from a desktop screen. We created and presented the experiment using the INQUISIT Millisecond software package (Inquisit 5.0, 2016) on an Intel Core i5-7500 CPU computer with an 85Hz, 24-inch CRT Monitor. All stimuli and instructions were presented against a black background.

Participants first practiced the dot probe task in two blocks of 16 practice trials, with an equal chance of each trial including a combination of i) CS+ and CS-, ii) CS+ and goal or iii) CS- and goal stimulus. There were four ways that each combination could be presented and therefore 12 possible trial combinations. Of these, eight trials were randomly chosen where the cues were shown for 250 ms and another eight trials were randomly chosen where the cue stimuli were shown for 30 ms.

Participants then completed three practice blocks of the goal task, in which they were exposed to the fear conditioned stimulus (CS+). In the instructions for the first block, we told participants that they would see colored rectangles followed by a question mark, and that one of these colored rectangles would be followed by an unpleasant sound from time to time. We told them to learn which rectangle would be followed by the white noise. During the first block of practice goal trials (six trials), participants saw the CS+ twice followed by the white noise, and the CS+ by itself on one occasion. The remaining three trials presented a filler stimulus twice and the CS- once.

The instructions for the second block of the practice goal task told the participants that they would see a separate rectangle which would act as a goal-relevant stimulus. We did then show the goal-relevant stimulus on the screen. We told participants that they should press the space bar every time they saw the goal stimulus (in the goal task) and after the question mark that followed, but not to press the space bar if any other stimulus was present on the screen. During the second block of practice goal trials (seven trials), the goal stimulus was presented twice and the CS+ was presented once, but without the white noise. The remaining four trials presented both the filler stimuli and the CS- twice.

During the third block of the practice goal trials (eight trials), the goal stimulus was shown three times, and the threatening stimulus was shown once more in conjunction with the white noise. The remaining four trials presented both a filler stimulus and the CS- twice.

Hereafter, participants practiced both the dot probe and goal task together in 24 trials (12 dot probe trials and 12 goal task trials) with each individual goal task trial preceded by a dot probe trial. The 12 dot probe trials presented each trial type equally often (goal vs. CS+, goal vs. CS-, CS+ vs. CS-) and in all four possible combinations of cue and probe locations; cues were shown for 250 ms. The 12 trials in the goal task consisted of six filler trials; in the remaining six trials of this task, CS+, CS-, and the goal stimulus were each shown twice. The CS+ was followed by the noise one time.

Participants then completed the test phase. The test phase consisted of two separate blocks of the combined task (each block containing 48 dot probe trials and 48 goal trials) that varied in how long they presented the cues (30 ms, 250 ms). The order of these blocks was counter-balanced between participants. The 48 trials of the dot probe task did show each trial type (goal vs. CS+, goal vs. CS-, CS+ vs. CS-) equally often. As in the practice phases, each cue stimulus was presented on half of the trials in the upper location and on the other half in the lower location. Each cue predicted the probe location correctly on half of the trials. The 48 trials in each block of the goal task consisted of eight trials presenting the CS+ (with four of these trials being followed by the US, i.e., the white noise), eight trials showing the goal stimulus, eight trials showing the CS-, and the remaining 24 trials presenting filler stimuli. The order of the trials of both tasks was determined randomly for each participant. The order of the attention task and goal task trials was determined independently. Hence, the cues that were presented in an attention trial were not predictive of the stimulus that would appear in a consequent trial of the goal task.

Participants then completed questions about the goal task. First, participants indicated whether they expected a sound after each (i.e., purple/blue/yellow) stimulus with answers rated from 1 (*never)* to 7 (*always)*. Then, participants reported how much they were afraid during the presentation of a purple/blue/yellow stimulus with answers rated from 1 *(not at all)* to 7 *(very much)*. Participants also indicated how threatening and unpleasant the sound was with possible answers from 1 *(not at all)* to 7 *(very much)*. Finally, participants completed the State Trait Anxiety Inventory-T (STAI-T). This questionnaire analyses the level of trait anxiety in participants (Spielberger, 1983) by asking them 20 questions relating to their general feelings on a four-point scale from 1 *(almost never)* to 4 *(almost always)*, i.e., “I am happy”. Hereafter, participants answered some demographic questions.

Awareness Task

In this phase of the study, a fixation cross appeared for 500 ms. In half of these trials a colored rectangle was then shown in the middle of the screen for 30 ms. During the other half of the trials, there was no rectangle present. Participants were asked to press “1” on the number pad if they had seen a rectangle or “2” if they had not seen a rectangle. This was done to confirm that participants could detect the rectangles in the dot probe trials at 30 ms. There were 76 trials (16 practice and 60 main trials) of this attention task. In the practice phase, there were two CS+, two CS-, two goal, and two filler trials and eight trials with no rectangle present. In the test phase, there were 10 CS+, 10 CS-, and 10 goal trials and 30 trials with no rectangle present. Trials were shown in a random order, with an intertrial interval of three seconds.

Results

Manipulation Checks and Goal Task

Performance in the goal task was accurate (average error rate 1.79%). Participants rated the white noise as unpleasant ($M = 5.20$, $SD = 1.40$) and threatening ($M = 4.70$, $SD = 1.37$); both values are significantly different from the midpoint of the respective scale (3.5), noise unpleasant: $t(29) = 6.65$, $p < .001$, $d_z = 1.23$, noise threatening: $t(29) = 4.80$, $p < .001$, $d_z = 0.89$. They reported expecting the white noise after the CS+ ($M = 5.17$, $SD = 0.91$) significantly more than after the goal stimulus ($M = 1.20$, $SD = 0.48$) or CS- ($M = 1.33$, $SD = 0.92$); *t*s (29) > 15.79, *p*s < .001, $d_{zs} > 2.92$. They also reported being more afraid of the CS+ ($M = 4.27$, $SD = 1.82$) than the goal ($M = 1.77$, $SD = 1.01$) or the CS- ($M = 1.47$, $SD = 1.31$); *t*s (29) > 7.25, *p*s < .001, $d_{zs} > 1.34$.

Awareness of rectangles at 30 ms

We ran four one-sample t-tests to analyze if participants correctly reported the presence or absence of each kind of stimulus (goal, CS-, CS+, no rectangle) in the awareness task, see also Table 1. As participants had a 50% chance of reporting the correct answer by chance alone, we used a test value of 0.50 for these one-sample t-tests. Participants correctly detected the presence or absence of a stimulus significantly above chance for all four stimuli, *t*s (29) > 44.44, *p*s < .001, d_{zs} > 8.24. Participants correctly responded between 96-97% of the time (*SDs* = 0.04 – 0.06).

Main results[1]

Incorrect trials in the dot probe task were removed from the analyses (1.84% of all trials). Trials with response times of less than 150 ms and greater than three standard deviations higher than the mean (in this case greater than 950 ms) were also excluded from the analyses (1.67% of all trials).

Following the approach by Liu et al. (2020), we first conducted a 3 (trial type: goal vs CS-, CS+ vs CS-, CS+ vs goal) x congruency (congruent, incongruent) x 2 (timing: 30 ms, 250 ms) repeated measures ANOVA across all trials. We found a significant interaction between trial type and congruency, $F(2,28) = 11.04$, $p < .001$, $\eta^2p = .44$, 90% CI [.18, .58]. All other effects were not significant, *F*s < 2.40, *p*s > .13, $\eta^2ps < .08$.

To explore the interaction between trial type and congruency, we conducted three separate t-tests on the different trial types (CS+ vs goal, CS+ vs CS-, goal vs CS-) within the dot probe task.[2] To this end, we averaged reaction times for congruent and incongruent trials across the two presentation times (30 ms, 250 ms). Please see also Table 2 and Figure 2.

Threat versus Control Trials

First, we analyzed the effect of threat congruency (threat congruent, threat incongruent) on response times in trials with a control and threatening stimulus. There was no significant difference, $t(29) = -.73$, $p = .472$, 95% CI [-20.95, 99.94], $d_z = 0.13$. These results suggest that contrary to our prediction, threat did not attract attention over the control stimulus (CS-).

Goal versus Threat Trials

We then focused on trials with goal and threatening (CS+) stimuli. Trials where the visual probe was congruent with the goal stimulus had significantly quicker response times (M = 399.69 ms, SD = 106.05 ms) than trials where the visual probe was congruent with the CS+ (M = 433.98 ms, SD = 105.08 ms), suggesting that participants paid more attention to the goal than the CS+, $t(29) = -3.64$, $p = .001$, 95% CI [-53.58, -15.00], $d_z = 0.67$.

Goal versus Control Trials

Finally, we analyzed the effect of goal congruency (goal congruent, goal incongruent) on response times in trials with a goal and a control stimulus (CS-). Trials with a visual probe congruent with the goal stimulus were significantly faster (M = 407.06 ms, SD = 103.41 ms) than trials with a visual probe congruent with the CS- (M = 434.07 ms, SD = 106.06 ms), suggesting that the goal stimulus attracted more attention than the CS-, $t(29) = -3.58$, $p = .001$, 95% CI [-42.43, -11.59], $d_z = 0.66$.

Trait Anxiety. Next, we analyzed the effects of trait anxiety. Given that we expected that trait anxiety would affect an attentional bias towards threat over other stimuli (rather than general reaction times across conditions), we obtained attentional bias difference scores for conditions presenting the threatening stimulus (i.e., goal vs. threat stimuli and threat vs. control stimuli) in each participant. The difference scores were obtained by subtracting the average response time when probes were shown in a location congruent with the threat stimulus from the average response time when probes were shown in a location congruent with the goal or the control stimulus. Positive scores indicate an attentional bias towards the threat stimulus. A score around zero would indicate a lack of preference in attention. We calculated these scores for both 30 ms and 250 ms cue presentation times.

A mixed linear model analysis was performed on these bias scores with the *lmer* function within the *lme4* package version 1.1-27.1 (Bates et al., 2015). Two dummy variables were used to code the trial types (threat vs. control = -1; threat vs. goal = 1) and the presentation duration conditions (short = 1; long = -1). We also included the interaction term between these two conditions. In addition, we z-standardized the STAI-T scores and included them as well as their interactions with the conditions as predictors (results with raw STAI-T scores produced the identical results). The model also included the random intercept between participants. The analysis did not show any significant effects (Table 3). However, as the present study only included 30 participants, we had sufficient power to detect only large-sized effects; thus, any interpretations of individual differences will be limited (cf. Bar Haim et al., 2007). We therefore return to the role of trait anxiety in the second study that has a larger sample.

Discussion

The pilot study supported to our hypothesis that goals attract attention in the presence of threat when the presentation duration is long. Importantly, we observed the same effect even when the presentation duration was short. These results suggest that goals may override attentional bias to threat even in an early stage of attentional processing. Nevertheless, one obvious limitation of the study is our failure to observe an attentional bias to threat in presence of control stimuli; this could be because the threatening stimulus used in our study might not have been sufficiently threatening. While participants had rated the white noise as unpleasant and threatening, the white noise was played at a lower decibel level (75 dBA) than the study it was based on (95 dBA; Vogt et al., 2013) and that found an attentional bias towards threat in the presence of control stimuli. This disparity in decibels may be crucial in provoking attention towards threatening stimuli in the presence of control stimuli. The sample size was also modest, especially to examine the effects of timing and trait anxiety. The main study addresses these two issues.

Main Study

The main study aims to test our hypotheses while presenting the white noise at 95 rather than 75 dBA. To increase statistical power, we also increased the sample size. This would also allow us to better understand the effect of the different timings. For instance, as can be seen in Table 2, attentional bias to goals in the pilot study may be stronger at longer presentation times despite the relevant interactions not being significant. The goal of the main study was to replicate the results from the pilot study with a larger number of participants. We also aimed to investigate the impact of trait anxiety on attention to threat.

Method

Participants and Design

We recruited forty-nine participants from the University of Reading, United Kingdom (11 male, 7 left-handed, average age 20.63 years, *SD* = 4.22 years) for this study. Forty-six of these participants were students, whilst the remaining three were staff workers.

The study involved again a 3 (Trial Type: goal vs CS-, CS+ vs CS-, CS+ vs goal) x 2 (Congruency: congruent, incongruent) x 2 (Timing: 30 ms, 250 ms) design. To establish the sample size, a power analysis for a repeated-measures design was conducted using G*Power. This analysis referred to the effect size of the CS+ versus CS- trials in Experiment 3 of Vogt et al. (2013) because we aimed to find a significant effect of the CS+ on these trials. We did not base it on the pilot study as this study used a different dBA. Based on the (d_z = .57) with alpha set at .05 and power at .80, it was estimated that 38 participants were required. We collected as many participants as we could within the available time frame and available course credits to permit the additional analyses of the STAI-T. The average STAI-T was 41.82 (SD = 11.75) which is comparable to other studies (e.g., Zuardi et al., 2008) and suggesting subclinical levels of anxiety. The sensitivity analysis shows that our sample size in this main study gives us 80% power to detect a small-to-medium-sized effect (Cohen's d = .41) and 95% power to detect a medium sized effect (Cohen's d = .53). This sample size also gives us 80% power to detect a medium-to-large-sized effect of trait anxiety (r = .39) on the attentional measures based on a summary-statistics approach (Murayama et al., 2020).

Participants were rewarded with credits after completion of the study. The study was approved to be in line with the guidelines of the University of Reading Research Ethics Committee.

Apparatus and Materials

The experiment was the same with the following changes. The sound was presented at 95 dBA. We changed the color of some of the filler stimuli in the goal task to be easier to discriminate from the CS+, CS-, and goal stimulus. The study was presented on a Dell Dimension 5000 computer with an 85 Hz, 19-inch CRT monitor. After the study, participants answered some questions about their age, gender, ethnicity, profession, hours of sleep and level of stress.

Results

Manipulation Checks and Goal Task

Performance in the goal task was accurate (average error rate 0.83%). Participants rated the white noise as rather unpleasant (*M* = 6.04, *SD* = 1.22) and threatening (*M* = 5.31, *SD* = 1.45). These values are significantly different from the midpoint of the respective scale (3.5), respectively, $t(48) = 14.53$, $p < .001$, $d_z = 2.10$; $t(48) = 8.20$, $p < .001$, $d_z = 1.18$. As expected, they reported expecting the white noise after the CS+ (*M* = 5.45, *SD* = 1.47) significantly more than after the goal stimulus (*M* = 1.55, *SD* = 1.08) or CS- (*M* = 1.41, *SD* = 0.91); *t*s(48) > 14.69, *p*s < .001, $d_{zs} > 2.11$. They also reported being more afraid of the CS+ (*M* = 5.12, *SD* = 1.83) than the goal (*M* = 1.82, *SD* = 1.18) or the CS- stimulus (*M* = 1.29, *SD* = 0.76); *t*s(48) > 11.27, *p*s < .001, $d_{zs} > 1.62$.

Awareness of rectangles at 30 ms. We ran four one-sample *t*-tests to analyze if participants correctly reported the presence or absence of each kind of stimulus (goal, CS-, CS+, no rectangle) in the awareness phase of the study. As participants had a 50% chance of reporting the correct answer by chance alone, we used a test value of 0.50 for these one-sample t-tests. Participants correctly detected the presence or absence of a stimulus significantly above chance for all four stimuli, *t*s (48) > 53.06, *p*s < .001, $d_{zs} > 7.66$, with the percentage of correct responses between 97% and 98% for all four stimuli (*SDs* 0.04 – 0.06), see also Table 1.

Main results

Incorrect trials in the dot probe task were removed from the analyses (1.28% of all trials).

Trials with response times of less than 150 ms and greater than 3 standard deviations higher than the mean (in this case greater than 793 ms) were also excluded from the analyses (1.89% of all trials). See Table 4 and Figure 3 for means and standard deviations of the RT data.

Main ANOVA

We first conducted a 3 (trial type: goal vs CS-, CS+ vs CS-, CS+ vs goal) x congruency (congruent, incongruent) x 2 (timing: 30 ms, 250 ms) repeated measures ANOVA to see if there was a significant interaction between trial type, congruency, and timing (cf. Liu et al., 2020). This interaction was indeed significant $F(2,47) = 11.49$, $p < .001$, $\eta^2p = .33$, 90% CI [.14, .46], in addition to interactions between trial type and congruency, $F(2,47) = 37.39$, $p < .001$, $\eta^2p = .61$, 90% CI [.45, .7], timing and congruency, $F(1,48) = 4.48$, $p = .040$, $\eta^2p = .09$, 90% CI [.002, .22], and timing and trial type, $F(2,47) = 3.92$, $p = .027$, $\eta^2p = .14$, 90% CI [.01, .28], all other effects, Fs < 3.7, ps > .061, η^2ps < .08. We followed the significant interaction between trial type, congruency, and timing up with ANOVAs per trial type.[3]

Threat versus Control Trials

First, we analyzed the effect of threat congruency (threat congruent, threat incongruent) and timing (30 ms, 250 ms) on response times in trials with a CS- and CS+. Unlike the pilot study, there was a significant effect of threat congruency, $F(1,48) = 16.12$, $p < .001$, $\eta^2p = .25$, 90% CI [.09, .4]. Trials where the visual probe was congruent to the CS+ were responded to significantly quicker (M = 404.01 ms, SD = 59.22 ms) than trials where the visual probe was congruent with the CS- (*M* = 419.07 ms, *SD* = 65.54 ms), suggesting that of these two stimuli, the CS+ attracted more attention. Neither the effect of timing nor the congruency x timing interaction were significant, *F*s (1,48) < 1, *ps* > .80.

Goal versus Threat Trials

We then analyzed the effect of goal congruency (goal congruent, goal incongruent) and timing (30 ms, 250 ms) on response times in trials with a goal stimulus and the CS+; as in the pilot study, in the goal-congruent trials, the probe was shown in the threat-incongruent locations, whereas in the goal-incongruent trials, the probe was shown in the threat-congruent locations. There was a significant effect of goal congruency, $F(1,48) = 22.40$, $p < .001$, $\eta^2p = .32$, 90% CI [.14, .46]. Trials where the visual probe was congruent with the goal stimulus had significantly quicker response times (*M* = 404.36 ms, *SD* = 65.84 ms) than trials where the visual probe was congruent with the CS+ (*M* = 429.93 ms, *SD* = 78.23 ms), suggesting that participants paid more attention to the goal than to the CS+. There was no effect of timing, $F < 1$, $p = .51$, $\eta^2p = .01$, 90% CI [.00, .1]. There was a significant interaction between congruency and timing, $F(1,48) = 7.66$, $p = .008$, $\eta^2p= .14$, 90% CI [.02, .28], indicating more attention to goal stimuli in 250 ms trials (*M* = 38.36 ms, *SD* = 57.65 ms) than in 30 ms trials (*M* = 21.77 ms, *SD* = 40.39 ms), but both scores were significant, 250 ms trials: $t(48) = -4.66$, $p < .001$, 95% CI [-54.92, -21.80], $d_z = 0.68$, and 30 ms trials: $t(48) = -2.21$, $p = .032$, 95% CI [-23.37, -1.16], $d_z = 0.32$.

Goal versus Control Trials

Finally, we analyzed the effect of goal congruency (goal congruent, goal incongruent) and timing (30 ms, 250 ms) on response times in trials with a goal and CS-. There was a significant effect of congruency, $F(1,48) = 43.25$, $p < .001$, $\eta^2p = .47$, 90% CI [.29, .59]. Trials with a visual probe congruent with the goal stimulus were significantly faster (*M* = 401.51 ms, *SD* = 67.80 ms) than trials with a visual probe congruent with the CS- (*M* = 428.15 ms, *SD* = 65.64 ms), suggesting that the goal stimulus attracted more attention than the CS-. There was also a significant effect of timing, $F(1,48) = 4.27$, $p = .044$, $\eta^2p = .08$, 90% CI [.001, .22]. Trials where the colored patches were shown for 250 ms induced significantly slower responses (*M* = 421.52 ms, *SD* = 72.94 ms) than when the colored patches were shown for 30 ms (*M* = 408.14 ms, *SD* = 62.07 ms). There was also a significant congruency x timing interaction, $F(1,48) = 25.73$, $p < .001$, $\eta^2p = .35$, 90% CI [.17, .49] indicating that the attentional bias scores for goal stimuli in 250 ms trials (*M* = 51.63 ms, *SD* = 42.50 ms) were significantly larger than attentional bias scores for goal stimuli in 30 ms trials (*M* = 1.65 ms, *SD* = 46.70 ms). Further, only the score at 250 ms was significant, $t(48) = 8.51$, $p < .001$, 95% CI [39.43, 63.84], $d_z = 1.20$, but not the score in 30 ms trials, $t(48) = .25$, $p = .81$, 95% CI [-11.77, 15.06], $d_z = 0.04$.

Trait anxiety

The effects of trait anxiety were analyzed in the two trial type conditions that included the CS+ (threat vs. control trials and threat vs. goal trials). The analysis was performed with the *lmer* function in the same manner as done in Pilot Study. Consistent with the previous ANOVA, this analysis revealed significant effects of trial types, $t(141) = -6.86$, $p < .01$, $d = 1.01$, and of presentation duration, $t(141) = 2.02$, $p = .046$, $d = 0.30$, which was qualified by a significant interaction, $t(141) = 2.31$, $p = .02$, $d = 0.34$. Effect sizes estimates are based on Murayama et al. (2020). In addition, we found a significant effect of STAI-T, $t(141) = 2.10$, $p = .04$. According to the summary-statistics approach (Murayama et al., 2020), this significant effect of anxiety corresponds to a medium-sized effect ($r = .29$). We did not find any significant interactions involving STAI-T (see Table 3). These results suggest that participants higher in STAI-T score showed a greater attentional bias to the CS+ (see also Figures 4 and 5).[4]

General Discussion

The present study examined whether people attend to signals of goals over threat at early (30 ms) and later (250 ms) stages of attentional processing. When using a sufficiently loud and thus threatening US (unconditioned stimulus i.e., a white noise) in the main study, the stimulus predictive of threat (CS+) attracted attention over the neutral control stimulus (CS-) at both presentation times. Attention allocation to threat did not differ between presentation times. However, when the CS+ competed with the stimulus relevant to a temporary goal in a secondary task, attention was allocated to the goal stimulus at both presentation times in both studies. This attentional bias to goals was stronger at the later processing stage in the main study. The attentional bias to goal stimuli in the presence of neutral control stimuli was only significant at the later processing stages. The findings suggest that attention to threat is modified by goals already at early stages of attention even if it is an imminent threat (i.e., a loud noise) and not just a symbolic threat such as images of dangerous people or animals (Liu et al., 2020). However, temporary goals evoke significantly larger attentional biases at later stages of processing.

These results challenge the assumption that threat attracts attention automatically (e.g., Vuilleumier & Huang, 2009). By this, our results not only replicate results from our lab (Study 3; Vogt et al., 2013) but also extend much emerging work on the impact of goals on attention to emotional and threatening information. In the previous study from our group (Study 3; Vogt et al., 2013), the presence of stimuli relevant to temporary goals prevented attention to fear-conditioned threatening stimuli at 250 ms. In a similar vein, Liu and colleagues (2020) demonstrated that temporary goals prevent attention to images of evolutionary threats at 350 ms. Our results extend these prior findings by demonstrating that attention to threat can be overwritten by goals even when the presentation duration is much shorter. Thus, our results add to findings suggesting that the processing of emotional information is not necessarily automatic but depends on the availability of cognitive resources (Pessoa et al., 2002; Yates et al., 2010). In line with this reasoning, it is increasingly recognized that top-down influences are of crucial importance in emotional attention (Pessoa & Adolphs, 2010; Vuilleumier & Huang, 2009; Abado et al., 2020). Pessoa and Adolphs (2010), for instance, reviewed evidence that cortical structures are heavily involved in the automatic processing of emotional information. This means that attentional bias to threat might only occur when observers hold a threat-related goal. We hope that future research will further clarify the attentional processing of threat and goals at early processing stages and the involvement of relevant brain regions.

Related to this argument, the main study revealed that attention to threat was stronger in in people high in trait anxiety. Visual inspection of the scatterplots representing the association between trait anxiety and the different attentional bias scores to threat (see Figures 4 and 5) shows that this association was strongest at 250 ms, and not at 30 ms, in trials representing the threat stimulus (CS+) with the goal stimulus (see also Footnote 4), though this difference is not significant. This could suggest that observers with heightened anxiety attend to threat because it is more relevant to them than the goal, especially when they have strategic control of attention. This interpretation challenges dominant theories of attention to threat in anxiety that portray this bias as automatic and out of the control of the individual (see Yiend, 2010, for an overview). Instead, the findings suggests that attention to threat is driven by controlled processes. This reading is in keeping with emerging evidence illustrating how attention is preferentially paid to threat but only when threat is relevant to the current goal of the individual (e.g., when participants had to search for emotional faces, Hahn and Gronlund, 2007; Brown et al., 2020; Van Dillen et al., 2017; Victeur et al., 2020; Vogt et al., 2017). Some authors have therefore argued that enhanced attention to threat in fear and anxiety may be underpinned, at least to some extent, by strategic processes such as current threat-related goals or expectations (Abado et al., 2020; Pessoa & Adolphs, 2010; Wells & Matthews, 1994) that are continuously activated in anxious individuals. We hope that future studies will further explore the role of top-down factors in understanding the attentional bias to threat seen in (sub-) clinical populations.

Another interesting result from this study concerns attention to goal-relevant stimuli when they are presented together with the control stimulus. In these trials, participants preferentially paid attention to the goal stimulus but only when the presentation duration was long. This contrasted with previous findings (e.g., Ansorge et al., 2009) as well as our hypothesis and suggests that goals bias attention only at the long presentation time when they do not compete with threat. These results suggest the role of top-down factors in attention to goal-relevant stimuli, raising the question about why goals win attentional competition over threat when they are presented together even in the short presentation duration. One possibility is that the presentation of threatening stimuli evokes arousal which has modulated the effects of goal. According to the arousal-biased competition theory (Mather & Sutherland, 2011), arousal induced when encountering something emotional modulates attentional processing in favor of goal-relevant over goal-irrelevant stimuli. Such complex effects of emotion are mediated by the noradrenergic mechanisms in the brain (Mather et al., 2016). Our results are in line with these notions and suggest that arousal evoked by threat may have selectively enhanced attention to goals even in the short presentation duration (see also Scherer, 2009).

In line with this reasoning, Liu and colleagues (2020) demonstrated an interesting dissociation between behavioral and neural ERP (event related potential) measures when a goal-relevant image and a threatening image are concurrently shown. Behaviorally, participants preferentially paid attention to the goal-relevant stimuli over the threatening image – the same results as those observed in our study. However, ERPs showed a significantly stronger N2pc response to the threatening image than to the goal-relevant image, suggesting that threat information is still processed in early stages of information processing. Thus, even when threat can be processed automatically as revealed in their ERP signals, this initial process does not automatically result in preferential attention to threat. When the goal-relevant stimulus is present together with threat, arousal evoked by early stages of processing of threat may help enhance attention to the goal-relevant stimulus via the noradrenergic mechanisms. Future research should investigate the role of noradrenergic systems in the interaction across threat, arousal, and goal in human attention.

Limitations

This research is not without limitations. First, we hope that future research will replicate and extend our findings, for instance, by using larger samples and/ or participants with (sub-) clinical levels of anxiety to enhance the understanding of the interplay between temporary goals and anxiety in attentional bias to threat. When not using highly anxious participants, the current trace conditioning procedure could be improved to raise the threat value of the CS+ such as by heightening the reinforcement schedule or using overlapping presentations of CS+ and the unconditioned stimulus (i.e., (forward) delay conditioning procedure, e.g., Bouton, 2007).

However, in the main study, participants already reported to experience the noise and the CS+ as very threatening. Further, extending the implemented methods to measure the processing of the stimuli will allow researchers to investigate the role of noradrenergic systems as discussed above. Future research could also compare action-relevant goal stimuli to action-relevant threat stimuli to control for action relevance of stimuli though previous studies have excluded this alternative explanation (Godara et al., 2020; Vogt et al., 2017).

Conclusion

In conclusion, the present findings suggest that the presence of temporary goals prevents attention to threat already at early stages of attentional processing. We hope that future work will extend these findings, for instance, by incorporating temporary goals in the development of interventions to modify attentional bias.

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Footnotes

[1] The analyses code is available here: https://osf.io/4sudn/.

[2] This approach is also justified by an ANOVA across the trials presenting the threatening stimulus (CS+) because this 2 (trial type: CS+ vs CS-, CS+ vs goal) x congruency (threat congruent, threat incongruent) x 2 (timing: 30 ms, 250 ms) repeated measures ANOVA shows a significant interaction between trial type and congruency, $F(1,29) = 10.56$, $p = .003$, $\eta^2p = .27$.

[3] This is validated by an ANOVA across trials showing the threatening stimulus (CS+) because this 2 (trial type: CS+ vs CS-, CS+ vs goal) x congruency (threat congruent, threat incongruent) x 2 (timing: 30 ms, 250 ms) repeated measures ANOVA also shows a significant interaction between trial type, timing, and congruency, $F(1,48) = 5.52$, $p = .024$, $\eta^2p = .10$.

[4] To validate these findings, we repeated these analyses using the ratings provided by participants on how threatening they experienced the loud noise to be and how afraid they were of the color of the CS+. We averaged these ratings as they were correlated, $r = 0.72$, to create a compound score representing participants' anxiety of the noise and the CS+ color. We then analyzed the effects of this score in the two trial type conditions that included the CS+ (threat vs. control trials and threat vs. goal trials) using the *lmer* function. Consistent with the previous analyses, this analysis revealed significant effects of trial type, $t(141) = -6.97$, $p < .001$, and of presentation duration, $t(141) = 2.05$, $p = .042$, which was qualified by a significant interaction, $t(141) = 2.34$, $p = .02$. Most importantly, we found a significant effect of the compound anxiety score, $t(141) =$

2.31, $p = .025$. We did not find any significant interactions involving the compound anxiety score, but the interactions between the compound anxiety score and trial type approached significance, $t(141) = 1.94$, $p = .054$, as well as the interaction between the compound anxiety score score, trial type, and presentation duration, $t(141) = -1.82$, $p = .071$. These results suggest that participants higher in anxiety of the noise and the CS+ showed a greater attentional bias to the CS+, especially at later presentation durations.

Table 1

Attention Check Means and Standard Deviations

Stimulus	% correct pilot study (*SD*)	% correct main study (*SD*)
Threat	97.33 (4.5)	97.35 (6.05)
Goal	97.33 (5.83)	97.76 (5.11)
Control	97.33 (5.21)	96.94 (6.19)
No Stimulus	96.22 (3.79)	97.28 (3.58)

Table 2

Mean RTs (and Standard Deviations (in ms)) as a Function of Trial Type, Congruence and Presentation Times in the Pilot Study

Trial type	Congruent[a]		Incongruent[b]		ABI[c]	
	30 ms	250 ms	30 ms	250 ms	30 ms	250 ms
Goal vs. control (CS-)	424.75 (114.58)	389.38 (105.77)	435.17 (128.02)	432.97 (104)	10.42 (67.43)	43.59 (67.26) **
Threat (CS+) vs. goal	438.16 (121.18)	429.81 (107.57)	410.06 (116.18)	389.32 (110.23)	28.1 (73.53) *	40.49 (74.72) **
Threat (CS+) vs. control (CS-)	419.97 (111.51)	404.08 (99.15)	430.12 (132.92)	404.93 (89.88)	10.15 (55.14)	0.86 (54.51)

Note. [a]Congruent refers to trials in which the probe replaced the picture category first mentioned under trial type.

[b]Incongruent refers to trials in which the probe replaced the picture category mentioned second under trial type.

[c]Attentional bias indices (ABI) were calculated by subtracting RTs on congruent trials from RTs on incongruent trials.

* Significant at the 0.05 level

** Significant at the 0.01 level

Table 3

Results of the Linear Effects Model on Trials Type Presenting Threat Using Trait Anxiety (STAI-T)

Pilot	*beta*	estimate	Std. Error	95% CI	df	*t*	*p*	sig
	Intercept	-1.2852	27.8673	[-55.79 53.22]	28	-0.046	0.9635	
	Trial type	-32.3768	27.3965	[-84.80 20.05]	84	-1.182	0.2406	
	duration	-39.0705	27.3965	[-91.50 13.36]	84	-1.426	0.1575	
	Trial type x duration	-14.5636	27.3965	[-66.99 37.86]	84	-0.532	0.5964	
	STAI-T	-0.2629	0.5456	[-1.33 0.80]	28	-0.482	0.6337	
	STAI-T x trial type	0.2503	0.5363	[-0.78 1.28]	84	0.467	0.642	
	STAI-T x duration	0.8922	0.5363	[-0.13 1.92]	84	1.664	0.0999	
	STAI-T x trial type x duration	0.3076	0.5363	[-0.72 1.33]	84	0.574	0.5678	
	random effects	Variance	Std. Dev					
	intercept	36.67	6.055					
Main Study	*beta*	estimate	Std. Error	95% CI	df	*t*	*p*	sig
	Intercept	-5.254	3.375	[-11.86 1.35]	47	-1.557	0.1262	
	Trial type	-20.313	2.96	[-26.03 -14.59]	141	-6.863	1.97E-10	***
	duration	5.968	2.96	[0.25 11.69]	141	2.016	0.0457	*
	Trial type x duration	6.829	2.96	[1.11 12.55]	141	2.307	0.0225	*
	STAI-T	7.142	3.41	[0.47 13.82]	47	2.095	0.0416	*
	STAI-T x trial type	4.185	2.99	[-1.59 9.96]	141	1.4	0.1638	
	STAI-T x duration	-3.739	2.99	[-9.52 2.04]	141	-1.25	0.2132	
	STAI-T x trial type x duration	-1.784	2.99	[-7.56 3.99]	141	-0.596	0.5518	
	random effects	Variance	Std. Dev					
	intercept	128.8	11.35					

Table 4

Mean RTs (and Standard Deviations (in ms)) as a Function of Trial Type, Congruence and Presentation Times in the Main Study

Trial type	Congruent[a]		Incongruent[b]		ABI[c]	
	30 ms	250 ms	30 ms	250 ms	30 ms	250 ms
Goal vs. control (CS-)	407.32 (67.57)	395.7 (68.23)	408.96 (56.74)	447.34 (68.81)	1.65 (46.7)	51.63 (42.5) ***
Threat (CS+) vs. goal	421.16 (72.67)	438.7 (83.23)	408.39 (58.48)	400.34 (72.85)	12.77 (40.39) *	38.36 (57.65) ***
Threat (CS+) vs. control (CS-)	404.67 (54.42)	403.34 (64.22)	418.87(64.73)	419.27(67.01)	14.2 (39.44) *	15.92 (32.58) **

Note. [a]Congruent refers to trials in which the probe replaced the picture category first mentioned under trial type.

[b]Incongruent refers to trials in which the probe replaced the picture category mentioned second under trial type.

[c]Attentional bias indices (ABI) were calculated by subtracting RTs on congruent trials from RTs on incongruent trials.

Figure captions

Figure 1. Schematic overview of an example trial of the combined dot probe and goal task in the experiments. The first three boxes depict the dot probe task in which the presentation of two cues was followed by a probe (black square) which had to be localized. The last two boxes display the goal task in which the presentation of a single stimulus was followed by the appearance of a question mark. Participants had to react to the question mark by pressing the spacebar when the single stimulus presented had been the goal-relevant stimulus. The cues in the dot probe task and the stimuli in the goal task consisted of colored patches. Cues were presented for either 30 or 250 ms in the dot probe task.

Figure 2. Mean dot probe reaction time for each trial type (see top label) and cue presentation duration (see bottom label) in the Pilot Experiment. Each color represents the cue (threat, goal, or control) that the probe replaced. Error bars represent one standard error of the mean.

Figure 3. Mean dot probe reaction time for each trial type (see top label) and cue presentation duration (see bottom label) in the Main Experiment. Each color represents the cue (threat, goal, or control) that the probe replaced. Error bars represent one standard error of the mean.

Figure 4. Scatterplots showing the association between trait anxiety (z-standardized STAI-T scores on y axis) and attention bias to threat (in ms, x-axis) in the trial types presenting the threat (CS+) stimulus with the goal stimulus.

Figure 5. Scatterplots showing the association between trait anxiety (z-standardized STAI-T scores on y axis) and attention bias to threat (in ms, x-axis) in the trial types presenting the threat (CS+) stimulus with the control stimulus.

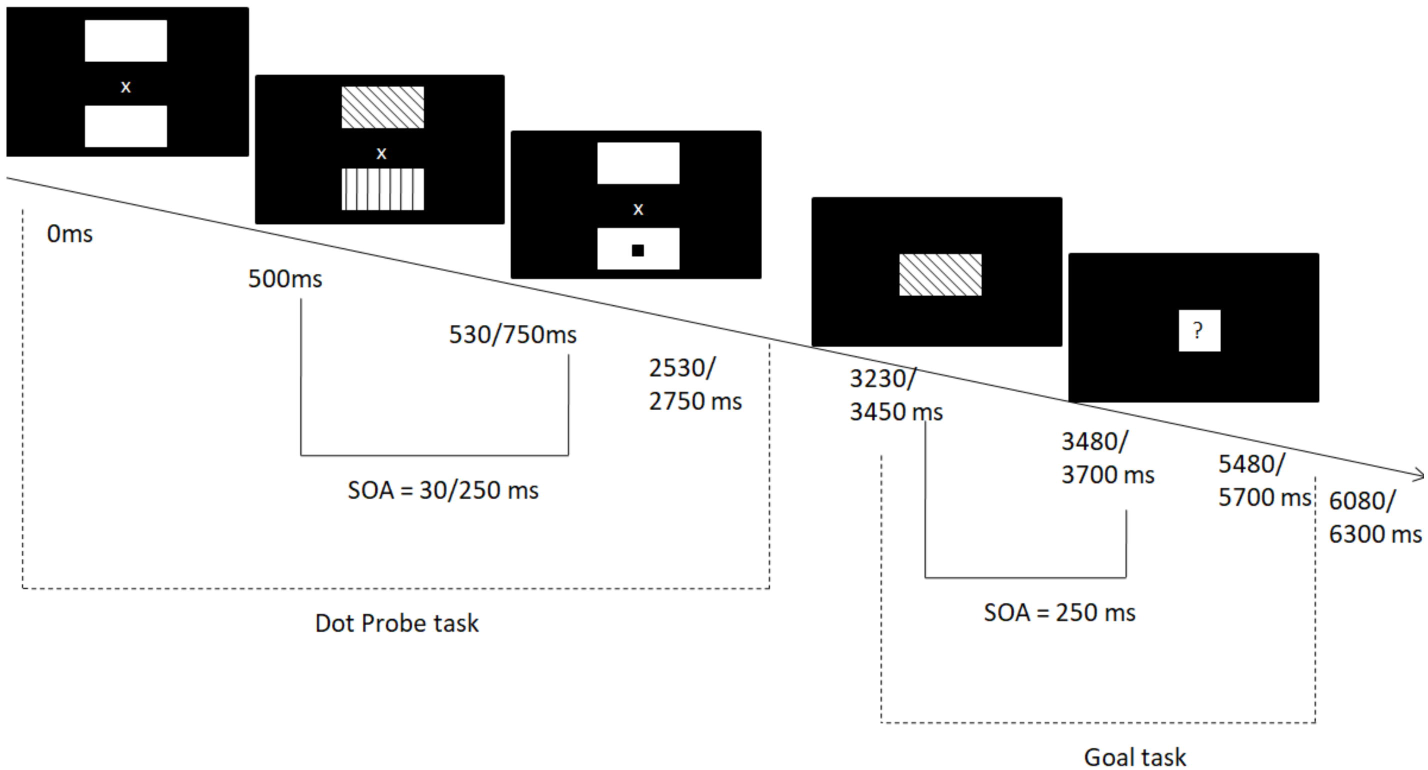

x
x
x
?
0ms
500ms
530/750ms
2530/
2750 ms
3230/
3450 ms
3480/
3700 ms
5480/
5700 ms
6080/
6300 ms
SOA = 30/250 ms
SOA = 250 ms
Dot Probe task
Goal task

Figure 1.

Figure 2.

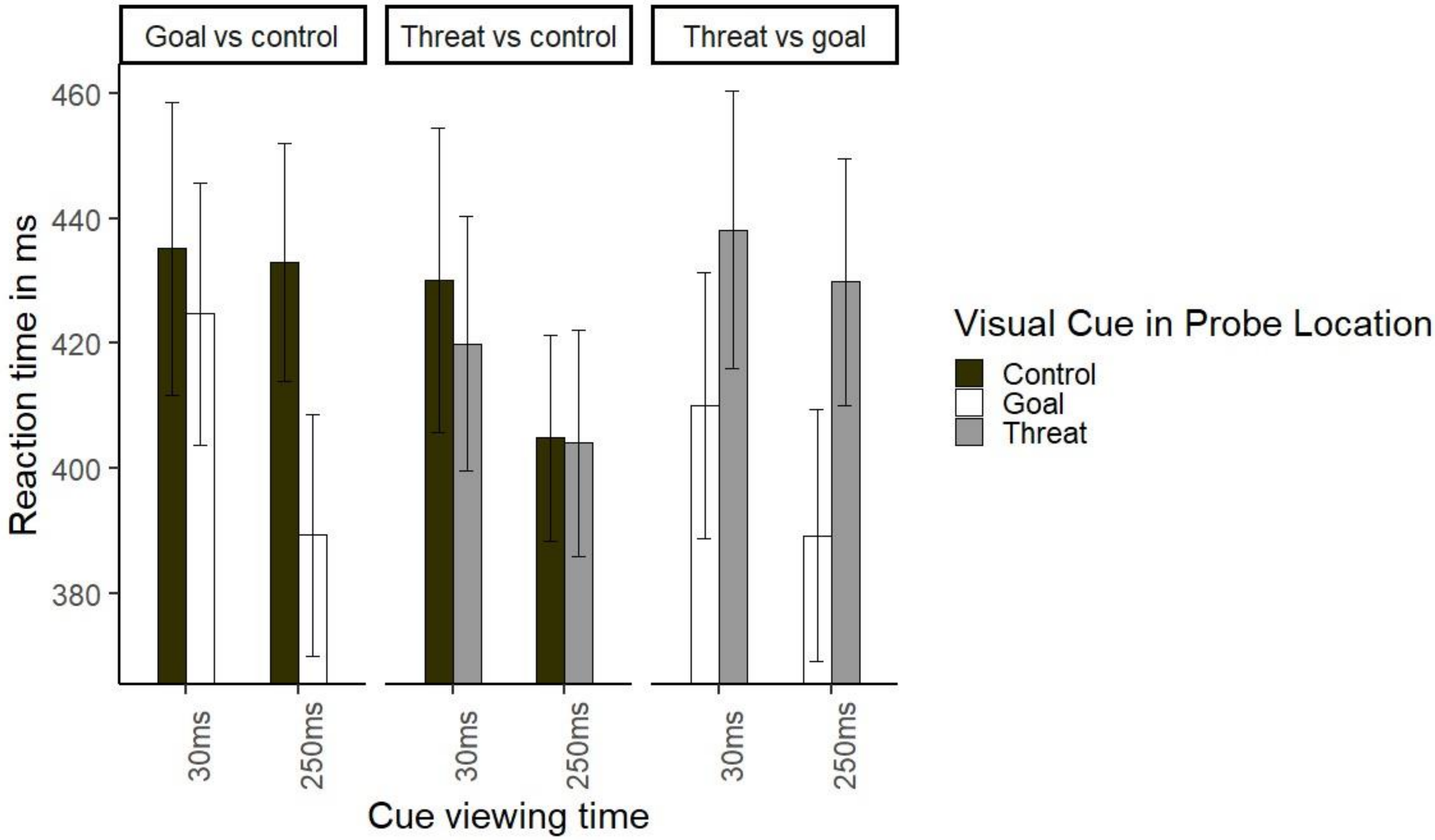

Goal vs control
Threat vs control
Threat vs goal
460
440
420
400
380
Reaction time in ms
30ms
250ms
30ms
250ms
30ms
250ms
Cue viewing time
Visual Cue in Probe Location
Control
Goal
Threat

Figure 3.

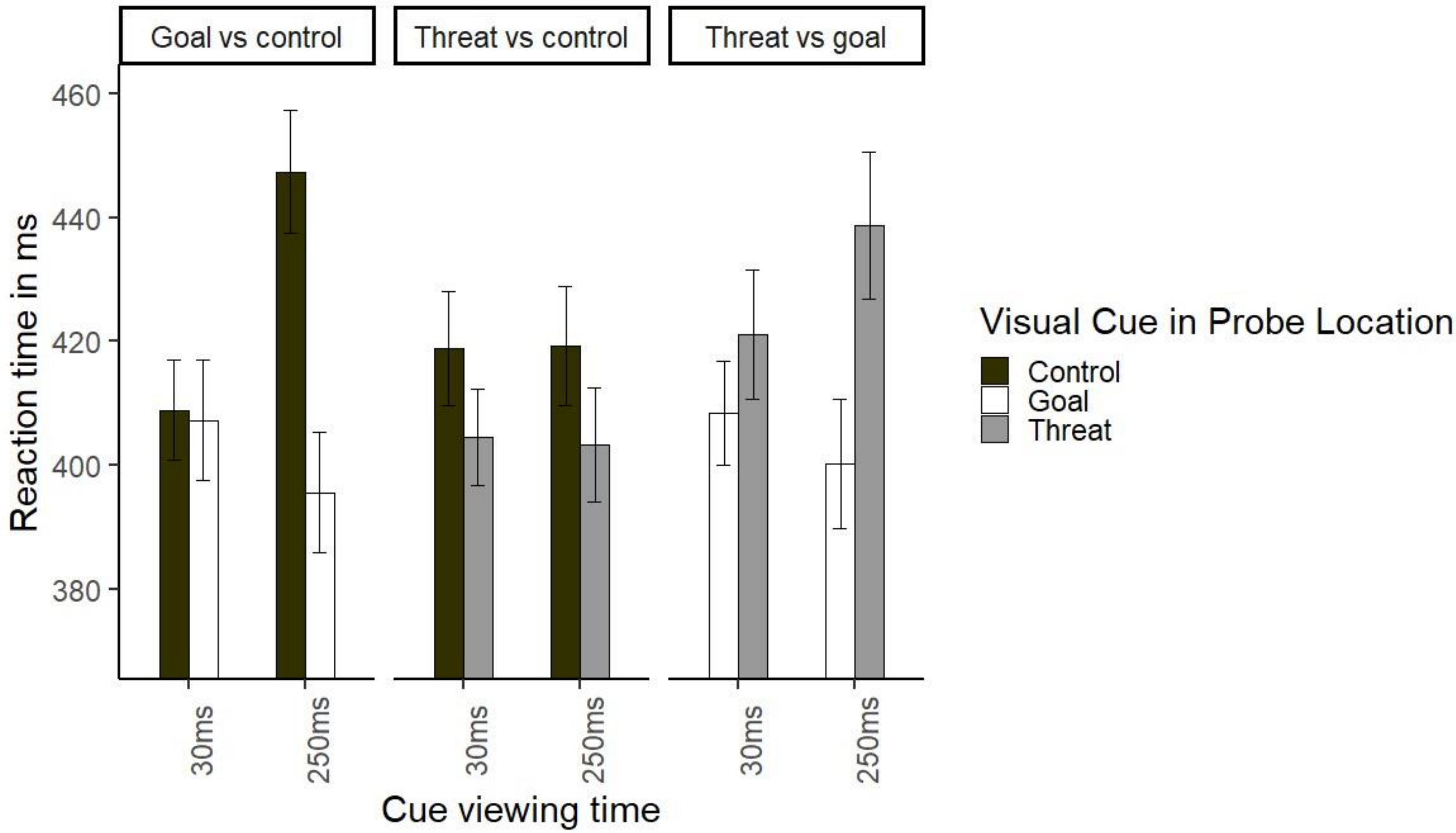

Goal vs control
Threat vs control
Threat vs goal
460
440
420
400
380
Reaction time in ms
30ms
250ms
30ms
250ms
30ms
250ms
Cue viewing time
Visual Cue in Probe Location
Control
Goal
Threat

Figure 4.

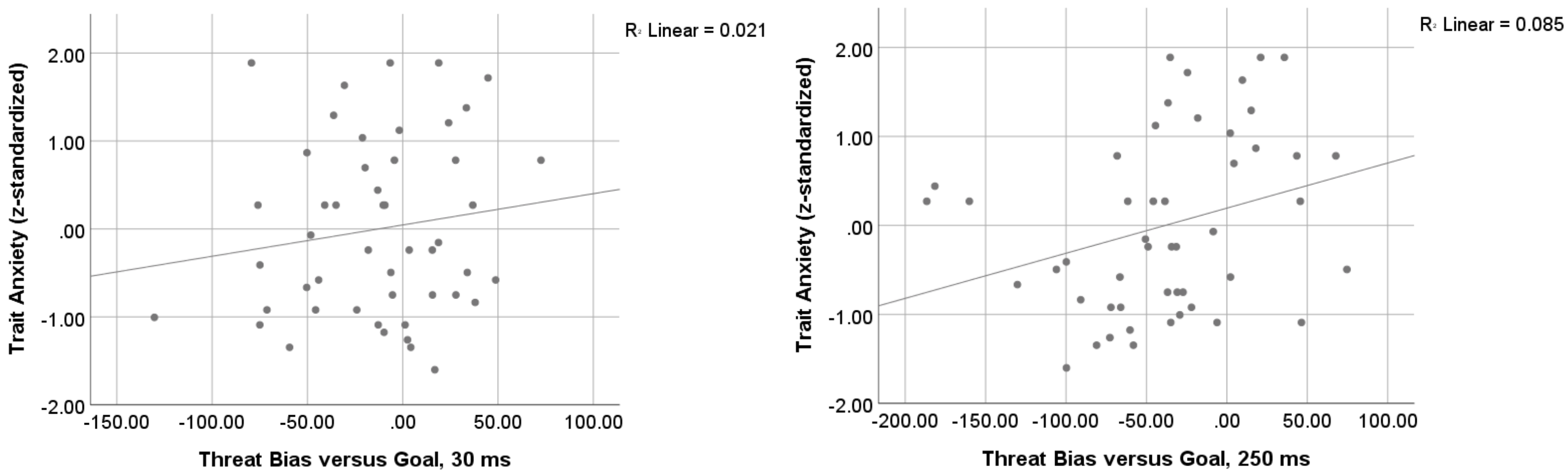
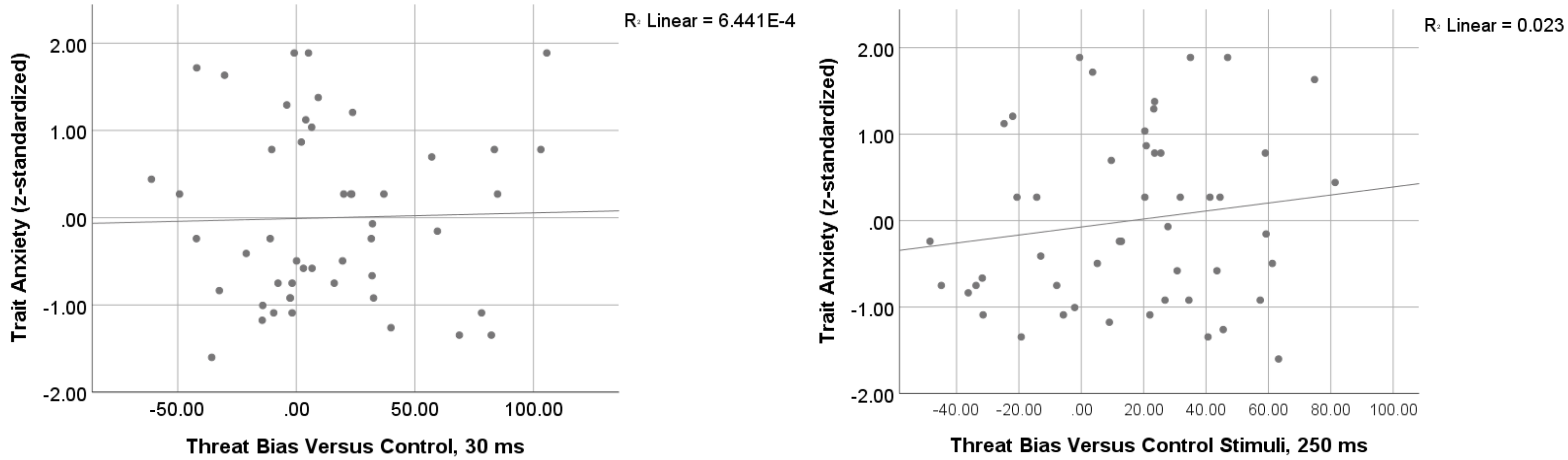

R² Linear = 0.021
Trait Anxiety (z-standardized)
2.00
1.00
.00
-1.00
-2.00
-150.00
-100.00
-50.00
.00
50.00
100.00
Threat Bias versus Goal, 30 ms
R² Linear = 0.085
Trait Anxiety (z-standardized)
-200.00
-150.00
-100.00
-50.00
.00
50.00
100.00
Threat Bias versus Goal, 250 ms

Figure 5.


R² Linear = 6.441E-4
Trait Anxiety (z-standardized)
2.00
1.00
.00
-1.00
-2.00
-50.00
.00
50.00
100.00
Threat Bias Versus Control, 30 ms
R² Linear = 0.023
Trait Anxiety (z-standardized)
2.00
1.00
.00
-1.00
-2.00
-40.00
-20.00
.00
20.00
40.00
60.00
80.00
100.00
Threat Bias Versus Control Stimuli, 250 ms