Threat and attention: Effects of other-directed punishments on automatic attentional performance

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Abstract

Previous studies have demonstrated that the speed and accuracy of visual spatial attention can be enhanced when one's performance is incentivized with punishments or rewards toward oneself. The primary objective of the present study was to determine whether this motivational effect on exogenous attentional performance is extended to situations where others' physical integrity is at risk. Second, we aimed to determine whether one's sensitivity to punishments, as measured by the Behavioral Inhibition Scale (BIS), has an enhancing effect on attentional performance in threatening conditions. To probe these questions, we set up a dyad experiment, in which one participant completed an exogenous spatial cueing task. During the task, we manipulated participant motivation by the threat of electric shocks directed either toward the task performer, their co-participant, or neither. The shock delivery was based on the performer's task performance. Our results showed no differences in performance between the three conditions. This contradicted our hypotheses and suggests that other-directed or self-directed threat does not lead to increased automatic attentional performance. Regarding BIS, we found that high-BIS individuals, relative to low-BIS individuals, have increased attentional reaction times during other-directed threat, but not during self-directed threat. This finding also contradicted our hypothesis. Therefore, we suggest that high sensitivity to punishments may lead to poorer attentional performance when others are at risk.

Layman's Abstract

In this study, our main goal was to understand whether other-directed threats can improve attentional performance – namely, the ability to identify briefly presented visual stimuli rapidly and accurately. This question stemmed from earlier findings demonstrating that people tend to detect such stimuli with a higher accuracy and decreased reaction times, when they expect a punishment for an insufficient performance. Moreover, our secondary goal was

to determine whether higher individual levels in sensitivity and tendency to avoid punishments can improve reaction times in such scenario. We investigated these questions by arranging an anonymous two-participant experiment. Here, one participant completed a computer task in which they aimed to detect specific stimuli as accurately and rapidly as possible. During the task, if the performing participant did not perform at a sufficient level, either the performer, their co-participant, or neither, could be given an electric shock through their fingers. Overall, the findings from this experiment contradicted our expectations. First, our results indicated no differences in reaction times or detection accuracy between the three electric shock conditions, suggesting that attentional performance is not improved in situations where others are at risk of punishment. Second, for individual differences in punishment avoidance, we found that individuals with a lower tendency to avoid punishments reacted more rapidly in the task, relative to those with higher tendency for punishment avoidance.

Threat and attention: Effects of other-directed punishments on automatic attentional performance

Visual attention plays a significant role in the detection of threats in one's environment, as the human visual attention system is fine-tuned to rapidly detect objects that might pose a risk to one's survival (Hollis, 1982; Öhman & Mineka, 2001; Bradley, 2009). This has been demonstrated through studies indicating that fear-relevant stimuli, such as potentially dangerous animals, are detected faster than non-fear-relevant stimuli. One example of this phenomenon is presented by Öhman et al. (2001), where the participants were instructed to detect specific targets from picture grids containing targets and distractors. When evolutionarily fear-relevant stimuli (snakes and spiders) were set as targets, they were detected more accurately, and with fast reaction times (RTs). In comparison, fear-irrelevant stimuli (flowers and mushrooms) as targets, with fear-relevant stimuli as distractors, led to poorer accuracy and slower RTs. This rapid detection of fear-relevant stimuli is automatic and may even occur outside of conscious perception of the stimuli (Öhman & Mineka, 2001). For example, subliminally presented fear-relevant stimuli tend to cause a reaction, as indicated by various psychophysiological measurements, such as increased skin conductance (e.g. Williams et al., 2004).

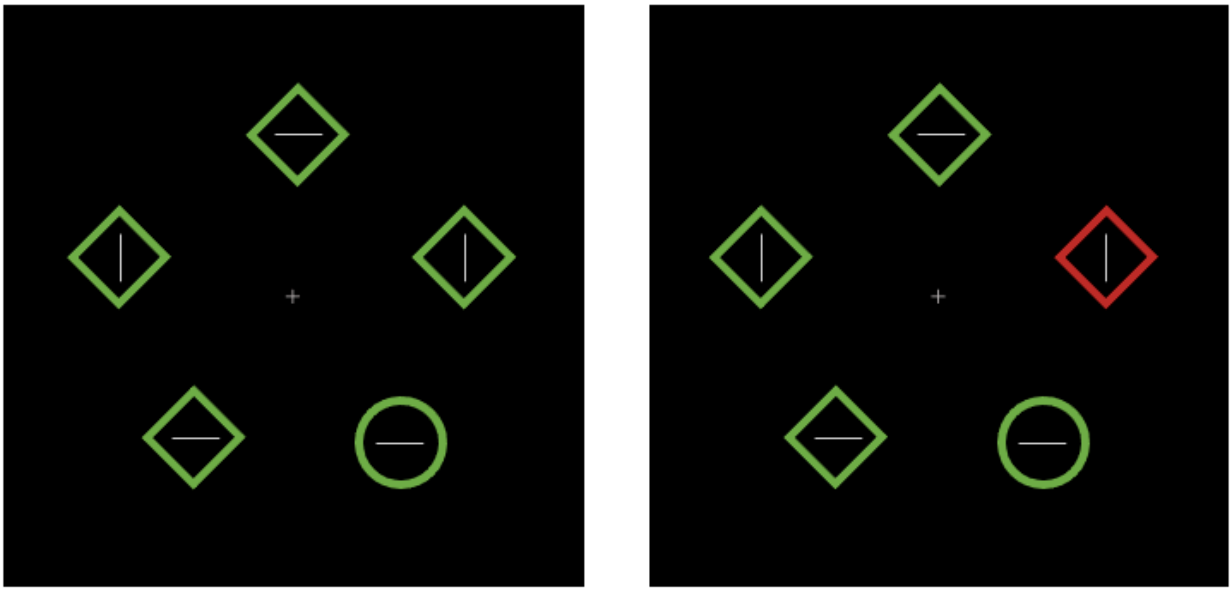
Mechanisms of Attention

The aforementioned attentional capture is referred to as *exogenous,* or bottom-up attention. It functions as one of the two mechanisms of spatial attention, the other one being *endogenous,* or top-down attention. Exogenous attention is driven by the visual saliency of stimuli – it can be captured by stimuli with sufficiently differing characteristics from its surroundings; physical saliency of stimuli can be defined by characteristics such as luminance, color, orientation, or motion (Yantis & Jonides, 1984; Theeuwes, 1991). For example, a stimulus with a sudden onset, such as a flashing light tends to capture one's attention involuntarily. Moreover, as discussed above, threatening and otherwise emotional stimuli appear to cause an automatic attentional shift, implying that emotional stimuli capture attention exogenously; indeed, a body of evidence indicates that emotional stimuli are prioritized in attentional selection (for a review, see Carretie et al., 2014). However, some authors have challenged this viewpoint, such as Pessoa (2005), who argued that the evidence for complete automaticity in this regard is incomplete, mainly due to some discrepancies in the definitions and measurements of awareness and automaticity used in related studies. For example, some studies have used "subjective" markers for awareness, such as participant reporting, and others more "objective" criteria such as measurements of RTs or fMRI signals. Moreover, there appears to be substantial individual variability in the ability to detect briefly presented stimuli, indicating that stimuli that are ostensibly below the threshold of conscious recognition, can be detected by some participants.

In contrast to exogenous attention, endogenous attention operates through a conscious effort to shift attention based on current tasks and goals (Chica et al., 2013). In a way, exogenous attention acts as a disruptor to endogenous attention (Carretié, 2014), as performance in goal-driven behavior can be influenced by the presence of task-irrelevant salient stimuli. An example of such an effect is presented in Figure 1 (adapted from de Fockert et al., 2004, based on Theeuwes' (1991) experimental paradigm), which illustrates an experimental paradigm in which a salient stimulus (a red square) disrupts goal-driven behavior by capturing one's attention, leading to poorer task performance, as measured by RT and response accuracy.

Figure 1

An exogenous attention task based on Theeuwes' (1991) experimental paradigm



Note. An experimental paradigm adapted from de Fockert et al. (2004) (original paradigm by Theeuwes (1991)), in which the participant's task is to determine the orientation of a line inside a green circle. The control condition is shown on left. On right, the color of one square is manipulated, acting as a distractor to capture the participant's attention. This negatively affects their performance in the search task, as the differing color causes an automatic capture of attention towards the red square.

The performance of both attentional mechanisms can also be influenced by cues, which guide one's attention toward a desired location. Exogenous cues, such as an asterisk presented briefly in one's peripheral visual field before the target presentation, cause an automatic shift of attention toward the cued location (Posner, 1980). In contrast, endogenous cues initiate a controlled, voluntary shift in attention. For example, a centrally presented arrow pointing left or right guides one's attention toward the pointed location (Posner, 1980; Müller & Rabbitt, 1989). Both types of cues may either act as an advantage or disadvantage to attentional performance, based on their cue-target *validity*. That is, valid cues predict the location of a target correctly, whereas invalid cues predict the target location incorrectly. Valid cues are beneficial for attentional performance, as they assist one in orienting their attention toward a certain stimulus or location, leading to faster RTs. On the contrary, invalid cues require disengagement from the cue location, and a reorientation toward the target, leading to slower RTs (Posner, 1980). Moreover, endogenous and exogenous cues differ in their validity over multiple trials. Endogenous cues predict the target location correctly over 50% of the time (e.g. 70% of all trials), incentivizing one to use the cue as a guide to shift their attention. In contrast, exogenous cues correctly indicate the target location only 50% of the time, meaning that the incentive to intentionally shift attention toward the cued location is absent. Instead, the attentional shift induced by exogenous cues is caused by the saliency of the stimuli (Yantis & Jonides, 1990).

Attention and Motivation

Besides the visual saliency of stimuli, recent studies suggest that attentional performance can be influenced by motivational factors as well, such as punishments or rewards (for a review, see Watson et al., 2019). That is, when a punishment (such as an electric shock) or a reward (such as money) is associated with a stimulus, one's attentional performance may either be improved or impaired based on the context of the incentive. Moreover, this effect seems to be automatic and involuntary (Watson et al., 2019). For example, participants take more time to detect targets in visual search tasks, when punishment-associated stimuli are presented as distractors, indicating that stimuli associated with threats tend to capture attention involuntarily (e.g. Schmidt et al., 2014; Failing & Theeuwes, 2014). Similar effects of aversive outcomes on task performance have been demonstrated using primary reinforcers, such as electric shocks (e.g. Hopkins et al., 2016; Koenig et al., 2017), and secondary reinforcers, such as monetary losses.

While the aforementioned findings addressed cases where specific stimuli are associated with incentives, previous studies have also probed the effects of rewards and punishments, when such incentives are tied to attentional performance itself. For example, Engelmann and Pessoa (2014) investigated the relationship between motivation and exogenous spatial attention using monetary incentives. Here, the authors examined whether attentional detection sensitivity is heightened by motivationally salient conditions, that is when monetary losses or gains were based on one's performance. The participants performed a spatially cued localization task, in which they were instructed to discriminate the location of a target stimulus on a screen, in the presence of a distractor stimulus. The authors aimed to probe the effect of incentives on attentional orientation and reorientation, so before the presentation of the target and the distractor, a peripheral cue was shown; these cues were valid in 70% of the trials. The result of the study showed that during reorientation (i.e. invalidly cued trials), monetary punishments and rewards improved participants' detection sensitivity, which corresponds to the notion that motivational salience of stimuli can have an enhancing effect on attentional performance.

Threat Toward Others and Intuitive Prosociality

Besides the findings that self-directed aversive outcomes may influence one's attentional performance, there is a lack of research on whether a similar effect occurs when others are at risk of aversive outcomes, based on one's performance. Previous findings indicate that people tend to assign a higher value to aversive outcomes for others, relative to aversive outcomes for themselves. For example, Crockett et al. (2014) demonstrated that to reduce pain toward others, people are willing to pay more money, compared to when the pain is directed toward themselves. Similarly, Story et al. (2015) showed that participants preferred equal distributions of pain between themselves and their co-participants over selfish ones. Notably, participants even chose to receive pain themselves as a way to avoid inflicting pain on others.

Zaki and Mitchell (2013) argue for the *intuitive model of prosociality*, stating that prosociality, which refers to behaving in ways that benefit others (Pfattheicher et al., 2022), has a major intuitive component. This model challenges the *reflective model* of prosociality, which claims that self-interested behavior is the instinctive baseline for humans, whereas prosocial acts require conscious suppression of these selfish or individualistic tendencies. Zaki and Mitchell (2013) justified their argument based on recent findings indicating that 1) prosocial decisions tend to take less time than selfish ones (e.g. Rand et al., 2012), 2) people tend to make more prosocial decisions under time pressure or high cognitive load (e.g. Cappelletti et al., 2011), and 3) cooperative behavior is increased during rapid and intuitive decision making (e.g. Rand et al., 2012).

Similar to Zaki and Mitchell's (2013) conclusions, Lengersdorff et al. (2020) demonstrated that participants showed a higher proclivity toward protecting others from harm, in comparison to protecting themselves, in an implicit learning task. Here, the participants completed a task, in which their goal was to learn the association between two abstract symbols and painful electrical stimuli. Based on the experimental condition, the threat of painful stimuli was either directed toward the task performer or their co-participant. The participants' *choice optimality* was measured – the degree to which they made decisions that maximize the expected rewards or minimize expected losses. The results showed that participants made more optimal choices when protecting others from harm than when protecting themselves. Notably, as the learning occurred implicitly in the experiment, the authors concluded that these findings support the intuitive model of prosociality.

The Effect of Behavioral Inhibition

Furthermore, previous research has shown that there are individual differences when it comes to the effect aversive outcomes have on one's performance. This has been demonstrated using the BIS scale (Gray, 1997), which was developed to test for interpersonal differences in Behavioral Inhibition. BIS is part of Gray's (1997) Reinforcement Sensitivity Theory (RST), which aims to explain interpersonal differences in reward and punishment sensitivity. The activation of the BIS system is present in situations when there is a risk of an aversive outcome, which can be seen e.g. as a higher level of alertness when anxiety-relevant cues are present (Corr et al., 1997; Corr, (2004). In practice, high BIS individuals are more prone to learning aversive associations (Gupta & Shukla, 1989). Regarding automaticity, Poy et al. (2003) demonstrated that automatic detection of threat-associated peripheral stimuli is enhanced in high BIS individuals, as measured by RTs. Notably, some authors, such as Avila et al. (1999) have also demonstrated poorer learning performance in the presence of threat cues by high BIS individuals.

Still, as higher BIS tends to result in improved automatic attentional performance, this increased sensitivity to threat cues could also promote prosocial behavior indirectly. Specifically, it could act as an advantage in situations where avoiding other-directed aversive outcomes is based on automatic attentional performance. However, direct evidence of the connection between BIS and prosociality is currently lacking, and it is still unclear whether other-directed threat cues affect high-BIS individuals similarly to self-directed threat cues.

Current Study

As previous research on the association between threat and attention has mostly focused on threat toward self, in the current study we investigated if exogenous attentional performance is affected by the threat of direct punishment to self or others. Moreover, we investigated whether an individual's level of behavioral inhibition is associated with their performance on the attentional task. We set up an experiment, in which one of two mutually anonymous participants performed a spatial cueing task – a similar paradigm to the one used by Engelmann and Pessoa (2014). For the task, we used a 50% valid peripheral exogenous cue. Moreover, we manipulated participant motivation by threat, using non-painful electrical stimuli, which were based on task performance. The threat direction varied throughout the task depending on the experimental condition, in which either the performer of the task, the co-participant, or neither of the participants could receive electric stimulation. Besides the spatial cueing task, the performing participant completed the Behavioral Inhibition Scale (BIS) (Carver & White, 1994) questionnaire to measure their level of behavioral inhibition.

Hypotheses

I hypothesize that a threat of punishment either toward self or toward the other leads to enhanced attentional processing, that is, faster orienting and re-orienting. In the threat conditions, I expect faster reaction times and higher accuracy at the validly cued location relative to the safe condition and we expect faster reaction times and higher accuracy at the invalidly cued location relative to the safe condition. This hypothesis can be justified through the findings indicating that the threat of aversive outcomes to self improves exogenous attention (e.g. Öhman et al., 2001; Engelman & Pessoa, 2014) and that people tend to assign an equal or higher value to aversive outcomes toward others as compared to aversive outcomes toward themselves (e.g. Story et al., 2015; Crockett et al., 2014).

Second, I hypothesize that attentional performance is increased when by other-directed threat, compared to when the threat is directed toward the self. Specifically, I expect faster reaction times and higher accuracy in the Other threat condition, than the Self threat condition, irrespective of cue validity. This hypothesis is supported by the findings on people’s tendency to avoid other-directed harm more than self-directed harm (e.g. Lengersdorff et al., 2020), and the notion that prosocial behavior has a prosocial component (Zaki & Mitchell, 2013).

Third, I hypothesize that participants high in Behavioral Inhibition will perform better in the attentional cueing task during threat, as compared to participants low in Behavioral Inhibition. It has been argued that people with high BIS scores tend to detect threat-associated peripheral stimuli faster than low BIS individuals (Poy et al., 2003)

Therefore, I expect faster reaction times for high BIS participants in the Self and Other threat conditions, relative to low BIS participants, irrespective of cue validity.

Method

Design

This experiment was a dyad study, in which two mutually anonymous participants were assigned the roles of the performer and the receiver. The performer's role was to complete a computer task, whereas the receiver observed the performer's task performance through a computer monitor. We conducted this study with a 3x2 within-subject design, with the variables being threat (to self, to other, safe) and cue validity (valid, invalid). The threat conditions were blocked and counterbalanced between subjects. Each block consisted of 4 smaller blocks of 16 trials. The cues used in the task were 50% valid and cue validity and the target location were randomly presented, throughout each block. Target appeared on the left or right side of the fixation, and its location and orientation (horizontal, vertical) were randomized across trials. Target/distractor orientation was also counterbalanced and presented randomly within a block of trials.

Participants

A total of 20 Leiden University students participated in the experiment, of which 10 were performers, and 10 receivers (ages 18-32, the performer gender distribution was 3 males and 7 who reported their gender as *other*). The participants were recruited through the university participant recruitment website (ul.sona-systems.com), by distributing flyers, and through various social media channels. We excluded participants who: 1) had a lack of sufficient understanding of English, 2) had a history of cardiovascular, neurological, or psychiatric diseases/disorders, 3) currently used a pacemaker or other medical equipment, 4) had color blindness or vision that is not normal or corrected-to-normal. The study was approved by the Leiden social sciences ethics committee.

Stimuli and Apparatus

The cueing task was programmed in OpenSesame 3.8 (OpenSesame, 2022), and ran on a Windows PC. The stimuli were presented on a computer monitor, and a typical computer keyboard was used for the task. The task stimuli (see Figure 2) included the target, greyscale Gabor patches of vertical and horizontal orientation (height = 3.5cm, width = 3,5cm). The distractor stimuli used black-and-white Gabor patches of oblique orientation (height = 3.5cm, width = 3.5cm). The peripheral cue presented before the target and distractor was a black asterisk (height = 1.5cm, width = 1.5cm). The task stimuli were presented on a grey background.

For the administration of the electric shocks, the Digitimer Constant Current Stimulator DS7A was used with standard Ag/AgCl electrodes. During the task, a Tobii Pro eye tracker was used to measure the performer's pupil dilation, and chin rest to ensure a correct pupil dilation measurement.

To measure the performer's level of Behavioral Inhibition, the original 24-question BIS/BAS scale by Carver and White (1994) was used, with the statements responding to Behavioral Activation System (BAS) excluded. The seven-item scale measuring Behavioral Inhibition (BIS) consists of statements about self, such as "I worry about making mistakes", to which the respondent gives a response on a 4-point Likert scale ranging from 1 (*strongly agree*) to 4 (*strongly disagree*).

Procedure

The experiment was conducted in the laboratories of the Social Sciences faculty of Leiden University. To ensure that the participants remain mutually anonymous, we instructed them to wait at different locations before the start of the experiment. After arrival at the testing location, the participants were asked to read instructions for the experiment and to fill in the informed consent. We assigned the participants into dyads in which one participant got the role of the *performer*, while the other participant got the role of the *receiver*. The role assignment was done using a random number generator. To ensure anonymity during the experiment, we used a partition screen between the participants.

The experiment started with an electric shock calibration procedure, through which we ensured that the administrated shocks were unpleasant yet non-painful in their level of intensity. We administered shocks of increasing intensity to the participants (starting from 1.2mA), which they rated on a 5-point Likert scale for unpleasantness, and with a yes-no question for painfulness. When an intensity was reached that the participant rated as a 5 ("very unpleasant") but non-painful, for two trials in a row, this intensity was used throughout the experiment for the individual participant. The maximum possible intensity was 10mA, which was used if an unpleasantness rating of 5 was not reached earlier. The shock intensity was calibrated first for the performer. After completion, the receiver was asked to step into the lab and the shock calibration was done for them as well. To ensure anonymity, the performer was asked to put on hearing protection earmuffs during the receiver's shock calibration procedure.

After the shock calibration, the eye tracker was calibrated, after which the performer carried out the spatial cueing task (Figure 2). Each trial started with a fixation cross in the middle of the screen, which was followed by a peripheral cue (an asterisk) shown on either side of the fixation cross, for 100ms. Next, two Gabor patches were shown on both sides of the fixation cross for 100ms, one of which was horizontal/vertical (the target), and one was diagonal (the distractor). The target location was randomized and counterbalanced across trials. The Gabor patches then disappeared, and the task of the participants was to determine the orientation of the target (horizontal/vertical) as accurately and quickly as possible.

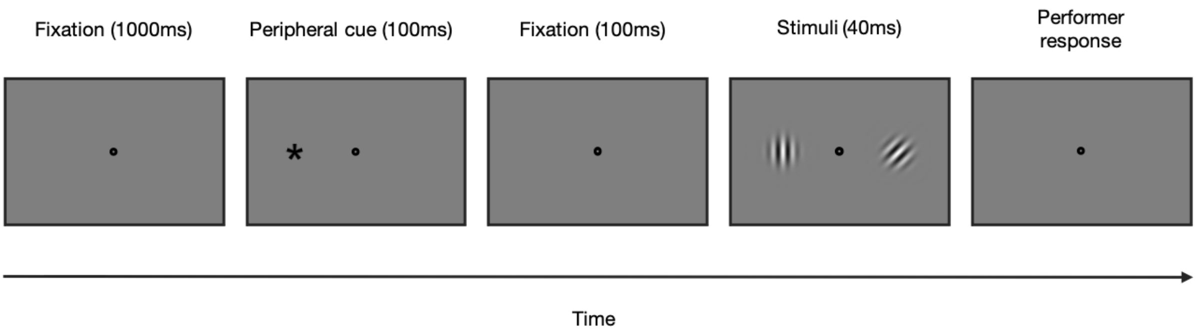
The task started with two 32-trial practice blocks. The practice blocks were followed by a 32-trial training block, in which the performer's mean reaction time was calculated. In total, there were 96 trials of practice and training. During the practice and the training, neither the performer nor the receiver could get shocked. Moreover, only during the practice and training trials, the fixation dot turned red whenever the performer responded incorrectly to a trial, to provide feedback for their performance.

After the training and practice blocks, the performer completed four 16-trial blocks of each of the three threat-based experimental conditions: *shock to self*, *shock to other*, and *safe*. The threat was operationalized by an unpleasant but painless shock to the finger toward either of the participants based on the condition. The order of these conditions was randomized and counterbalanced between participants. Instructions about the condition were presented before the beginning of each block: which participant could be shocked at the end of the block, and the RT and response accuracy requirements for preventing the shock. After each block, the performer was informed about their average RT and accuracy across the block, and whether either of the participants would get shocked. The electric shocks were used as a punishment based on the performer's performance on the cueing task which was assessed (7 out of 10 trials correct and RT faster than 200ms above their mean) every 32 trials. Before either of the participants received a shock, a notification of the incoming shock was shown on the screen, as well as an indication message after the shock was delivered. Each time the performer was shocked, they were asked to report the unpleasantness of the given shock on a scale from 1 to 5.

After the main task, the performer filled in online versions of four different forms: Behavioral Inhibition System (BIS, Carver & White, 1994), Empathy (TEQ, Kvaal et al., 2005), Trait Anxiety (STAI-T, Spielberger et al., 1983), and Social Value Orientation (SVO, Murphy et al., 2011). Out of these, the current paper focuses on BIS (in line with the second hypothesis). In the same set of questionnaires, the performer filled in their demographic information as well (age and gender).

Figure 2

One trial of the attentional task with a valid cue



Note. The object proportions are exaggerated here, in comparison to the actual task stimuli. The trial starts with a fixation dot presented in the middle of the screen, after which the cue (an asterisk) is shown for 100ms, on the left or the right side of the fixation dot (valid 50 percent of the time). Next, a screen with just the fixation is presented, followed by the stimuli presented for 40ms: one horizontal or vertical Gabor patch, and one obliquely oriented patch. After this, fixation is presented until the the performer responds.

Statistical Analyses

For the effect of threat on attentional performance, I conducted a repeated-measures ANOVA on RT and accuracy with the factors cue validity (valid, invalid) and threat (Shock to Self, Shock to Other, Safe). For the effect of behavioral inhibition on performance, I calculated the reaction time difference scores (DS) by subtracting RTs in the threat conditions (self, other) from the safe condition, for valid and invalid conditions separately. I performed a correlation analysis with the difference scores and performer BIS scores. For the statistical analyses, I disregarded all data points with RTs below 200ms or above 1452ms (2.5SDs above the mean). Moreover, the data of one participant had to be excluded as an outlier, as their mean RT was above the 2.5SD threshold.

Results

For the first hypothesis, I performed a two-way repeated measures analysis of variance (ANOVA) on reaction time and accuracy, where cue validity (valid, invalid) and threat (safe, self, other) were used as the within-subjects factors. Means and standard deviations are presented in Tables 1 and 2. First, the main effect of threat did not reach significance regarding RTs, F (2, 7) = 2.36, p = .16, partial eta squared = .40. Likewise, the main effect of cue validity did not reach significance regarding RTs, F (1, 8) = 2.55, p = .15, partial eta squared = .24. The interaction effect between threat and cue validity was non-significant as well, F (2, 7) = 1.93, p = .21, partial eta squared = .36.

Similarly, no significant results were found for threat on accuracy, F (2, 7) = .84, p = .47, partial eta squared = .19. The main effect of cue validity on accuracy was nonsignificant as well, F (1, 8) = 1.62, p = .24, partial eta squared = .17. However, for accuracy, the interaction effect between threat and validity reached significance, F (2, 7) = 5.36, p = .04, partial eta squared = .61.

As the interaction effect between threat and validity was significant, I conducted pairwise comparisons with a paired samples *t*-test, between validly and invalidly cued trials, for each threat condition separately. For all conditions, comparisons were nonsignificant (for the safe and other conditions, p's > .2). However, for the self-condition, the mean accuracy was higher in the invalid trials (M = 91%, SD = 6%) than in the valid trials (M = 83%, SD = 14%), and a near-significant effect was found, t (8) = -2.1, p = .07.

Finally, to examine the effect of behavioral inhibition, I correlated the DS of safe and threat conditions with BIS (Figure 3). Here, the DS displays the difference in reaction time between threat and safe conditions (presented on the y-axes in Figure 3); positive values indicate faster RTs in the threat condition relative to the safe condition, negative values indicate slower RTs in the threat condition relative to the safe condition, and a value of zero indicates no difference between the conditions. Assumptions for linearity and homoscedasticity were met. For both validly and invalidly cued trials, strong negative correlations were found between BIS and the other-directed threat, indicating poorer attentional performance in the other-directed threat conditions with higher BIS scores, for validly cued trials, $r = -.69$, $n = 9$, $p = .04$, and for invalidly cued trials, $r = -.73$, $n = 9$, $p = .03$. Moreover, there was no significant correlation between BIS score and self-directed threat – validly cued trials, $r = -.23$, $n = 9$, $p = .56$, invalidly cued trials, $r = -.36$, $n = 9$, $p = .35$, indicating no relationship between BIS scores and attentional performance regarding self-directed threat.

Table 1

Mean reaction times and standard deviations (SD) in ms in each threat condition

Threat	Valid	Invalid
Safe	557 (89) ms	587 (92) ms
Self	587 (125) ms	787 (107) ms
Other	551 (104) ms	560 (106) ms

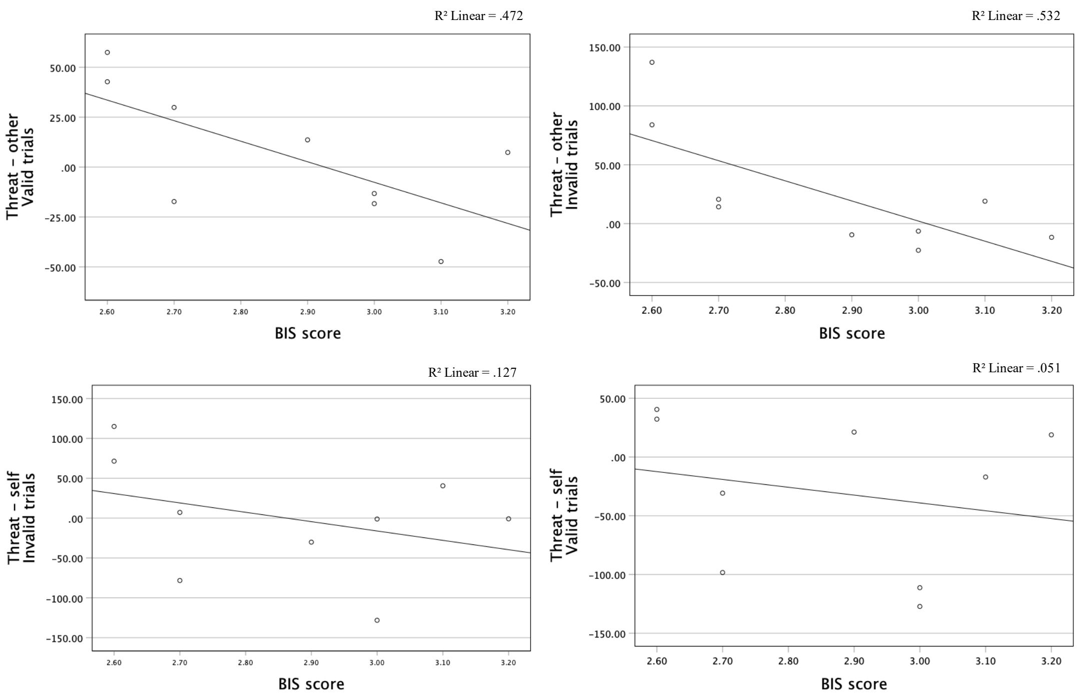
Table 2

Mean accuracies and standard deviations (SD) in each threat condition

Threat	Valid	Invalid
Safe	93 (5) %	86 (20) %
Self	91 (6) %	83 (14) %
Other	90 (6) %	86 (17) %

Figure 3

Correlations: Threat Conditions and Participant BIS Scores



Note. Reaction time difference scores are presented on the y-axes (threat condition RTs (Self, Other) minus safe RTs). On the first row, other-directed threat is plotted against participant BIS scores, separated by cue validity. On the second row, self-directed threat is plotted against participant BIS scores, separated by cue validity.

Discussion

The primary objective of this study was to investigate whether other-directed threats have an enhancing effect on exogenous attentional performance. We expected decreased RTs and increased accuracy during self- and other-directed threats relative to safe conditions. Moreover, we expected decreased RTs and increased accuracies during other-directed threat relative to self-directed threat. Our findings did not support these hypotheses. There was no significant difference in RT or accuracy between the self, other, and safe conditions, suggesting that self- or other-directed threats do not affect exogenous attentional performance. Furthermore, we found no significant effect of cue validity on RT or accuracy.

The secondary aim of this study was to determine whether one's level of behavioral inhibition (BIS) influences their attentional performance in threatening conditions. We expected faster RTs in both threat conditions (self, other) by individuals with high BIS sensitivity relative to individuals with low BIS sensitivity. We observed significant negative correlations with BIS scores and reaction times during other-directed threat, in both validly and invalidly cued trials. Contrary to our hypothesis, this suggests that high BIS individuals' exogenous attentional performance is impaired during other-directed threat. For self-directed threat, we found no significant correlation with BIS scores. This suggests no effect of BIS sensitivity on attentional performance when one's own physical integrity is at risk; these findings also contradicted our hypothesis.

Cue Validity

As mentioned, we found no significant effect of cue validity on performance, which contradicts a plethora of earlier findings demonstrating that exogenous peripheral cues cause an automatic shift toward the cued location (Posner, 1980; Müller & Rabbitt, 1989; Chica et al., 2013). One reason for this outcome could be related to the difficulty of the task. Posner (1980) made the notion that the strength of the cue validity effect tends to decrease as task difficulty or complexity increases. In our case, a similar effect of task difficulty might have influenced the outcome, considering e.g. that the stimuli presentation time was relatively short (40ms). The performer also needed to allocate their cognitive resources toward remembering the current receiver of shocks, which might have added to the difficulty and complexity of the task, leading to a weaker effect for cue validity. Notably, the lack of cue validity effect requires us to be cautious when interpreting the remaining results.

Threat and Attention

The current results contradict previous findings on the effects of punishments on attentional performance. First, Engelmann and Pessoa (2014) demonstrated that when exogenous attentional performance is associated with self-directed punishments, the speed and accuracy of attentional performance increase. In contrast, we observed no significant difference in attentional performance between the safe and the self-directed threat conditions. However, we did observe increased accuracies during self-directed threat in the invalidly cued trials relative to the valid trials, although this effect did not reach significance. Similarly to the latter results, Engelmann and Pessoa (2014) also demonstrated that exogenous attentional performance motivated by monetary punishments was significantly improved during reorientation (invalidly cued trials) only. A potential explanation for this effect could be that there are differences in the way threat-associated information is processed between the orientation and reorientation systems. Similar conclusions were drawn by Engelmann and Pessoa (2014) and Engelmann et al. (2009), but in the context of rewards: these authors suggested that the effect of motivational information is stronger on reorientation. These findings in combination with ours indicate enhanced efficiency of attentional reorientation in motivationally salient conditions. Still, this implication is tied to the fact that the effect of cue validity alone did not reach significance in our study, in which case we cannot make strong conclusions based on these findings on the interaction of cue validity and threat either.

Prosocial Behavior

Some earlier findings have demonstrated that people tend to prioritize avoiding other-directed punishments over the avoidance of self-directed punishments, such as electric shocks (Crockett et al., 2014). Additionally, it has been suggested that other-regarding, prosocial behaviors are often driven by intuitive, even automatic processes (Zaki & Mitchell, 2013; Rand et al., 2012). Our results were not in line with these findings. We observed no significant difference in RT or accuracy between the threat conditions, indicating that attentional performance is not improved by other-directed threats. However, alternative factors could also have caused this outcome. For example, Rand et al. (2012) suggested that there are individual differences in tendencies for intuitive prosocial behavior. They demonstrated that participants who reported benefitting from cooperative behavior in their day-to-day life were more likely to have more prosocial intuitive responses in the experimental task. Specifically, those cooperation-benefitting participants tended to respond more cooperatively than others in a decision-making task, under time pressure. Based on such findings, an alternative explanation for our results could be that due to the small number of participants in our study, there was little interpersonal variability, which then might have prevented the emergence of the effect of other-directed threat on performance.

Notably, while we found no significant effect for other-directed threat, this result does not necessarily demonstrate a lower level of prosociality among the participants. Specifically, Crockett et al. (2014) have suggested that incentive valence (the attractiveness or aversiveness of the outcome) and one's prosocial preferences interact. Their results showed that individuals with higher prosocial preferences had increased RTs in a context where aversive outcomes toward others depend on one's actions. Therefore, faster RTs in other-directed threat conditions are not necessarily indicative of the participants' stronger prosocial preferences. Based on the suggestion of Crockett et al. (2014), slower reactions in such conditions might imply higher prosociality, as individuals with high prosocial preferences tend to respond more slowly in aversive contexts. Nevertheless, we cannot draw strong conclusions on the matter yet without a direct measurement of the participants' prosocial preferences, such as a scale measuring Social Value Orientation (SVO) Murphy et al., 2011.

Behavioral Inhibition and Threat

Regarding BIS and threat, the current results are not in line with our hypotheses. First, we found no relation between BIS and the effect of self-directed threat on performance. This contradicts the previously made observation that high BIS individuals are more alert in threatening contexts (Corr et al., 2004) and learn aversive associations more efficiently (Gupta & Shukla, 1989). Overall, the current findings on BIS correspond to the other results of our study, regarding the lack of significant effect of self-directed threat or cue validity on performance across all participants. Therefore, it could be that a feature in the experimental design, such as task timings or perceived level of threat by participants led to the overall lack of effect. Furthermore, an alternative reason for the lack of significant difference in the self-threat condition could be that the range of BIS scores in our sample was relatively narrow: all scores fell between 2 and 3.5, on a range from 1 to 5. Potentially, the score variation was not large enough for the emergence of a significant effect regarding self-directed threat.

Moreover, we found that high BIS participants performed more poorly during other-directed threat, which indicates a reversed effect to our expectations. Here, the factors discussed above do not explain this result. One possible explanation could be that high BIS individuals are more sensitive to other-directed punishments, than self-directed ones, and that the effect was strong enough to emerge, even with a narrow score range. Some earlier findings support this notion to a degree. For example, Bos et al. (2013) demonstrated that in threatening environments, such as a bystander situation, high BIS individuals are more likely to take a passive role, relative to low BIS individuals. While such findings do not offer direct support for our conclusion that high BIS individuals might be more sensitive to other-directed threats, they suggest a differing functionality of BIS between social and non-social contexts. In our study, a social dynamic was present as well: the performer's actions were observed by the receiver, and their actions affected the receiver as well. Hypothetically, this sense of social pressure could have translated into poorer performance when other-directed punishments depend on one's actions.

Limitations and Future Directions

As mentioned, one limitation of the present study was that our sample size was relatively small, and consisted only of social science students. As suggested by the findings of Crockett et al. (2014), daily social environments can affect one's proclivity for intuitive prosocial behavior. Potentially, this effect might have skewed our results regarding the effect of other-directed threat, as our sample was small and consisted of participants who likely interact in similar day-to-day social dynamics. In future studies, besides a larger sample size, including a measurement for Social Value Orientation (Murphy et al., 2011) would help mitigate the effects caused by individual differences.

Besides sample size, our experimental design could also explain the lack of significant effects found in this study. First, it has been demonstrated that electric shocks cause fear and act as an effective aversive motivator in various scenarios when directed toward self or others (e.g. Clark et al., 2012; Crockett et al., 2014; Schmidt et al., 2015). Still, a variety of factors can play a part in how one responds to shocks. For example, some individuals appear to respond with humor, besides a fear response (Rhudy & Meacher, 2003). Similarly, externally induced emotional states can affect pain tolerance (Meagher et al., 2001). In our case, we observed varying reactions to the electric shocks in the calibration phase; for example, some participants seemed to be affected very little by the shocks, whereas others appeared more nervous. Moreover, the cutoff for shock intensity we used ("uncomfortable, but not painful") can be hard to define, which was evident in our experiment as participants evaluated the same shock intensities with varying ratings on different occasions. The overall conclusion from the notions discussed above is that manipulations of threat have a degree of uncertainty to them due to various contextual and personality factors. However, this could be mitigated in future studies by measuring psychophysiological responses to fear, such as skin conductance. This would allow for a more quantifiable approach to analyzing the effect of threat on performance.

Finally, as mentioned earlier, one limitation of the current study regarding BIS was that the scores varied relatively little between participants. Therefore, it is not possible to make definitive conclusions about the extremes of the BIS distribution from this data. Again, a larger random sample would provide a greater distribution in BIS scores as well, which would allow for more robust conclusions regarding the relationship between high BIS and threat-motivated attentional performance.

Conclusion

In the present study, we aimed to determine whether exogenous attentional performance is enhanced by other-directed aversive outcomes. Moreover, we aimed to determine whether increased sensitivity to aversive outcomes is associated with improved performance when others are at risk of punishment. Our findings suggested that the speed and accuracy of attentional capture and disengagement are not substantially enhanced when others' physical integrity is at risk. Moreover, contrary to our expectations, it appears that higher sensitivity to punishments has an impairing effect on attentional performance when others, but not themselves, are at risk. Overall, these findings further our understanding of how aversive motivational factors affect attentional performance as well as how interpersonal differences in threat sensitivity may play a part in this effect. Still, further research with larger samples and psychophysiological measurements is needed to establish more robust conclusions regarding threat, exogenous attention, and behavioral inhibition.

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