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Is it dangerous? The role of an emotional visual search strategy and threat-relevant training in the detection of guns and knives

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Article

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Is it dangerous? The role of an emotional visual search strategy and threat-relevant training in the detection of guns and knives

Abstract

Counter-terrorism strategies rely on the assumption that it is possible to increase threat detection by providing explicit verbal instructions to orient people's attention to dangerous objects and hostile behaviours in their environment. Nevertheless, whether verbal cues can be used to enhance threat detection performance under laboratory conditions is currently unclear. In Experiment 1, student participants were required to detect a picture of a dangerous or neutral object embedded within a visual search display on the basis of an emotional strategy ("is it dangerous?") or a semantic strategy ("is it an object?"). The results showed a threat superiority effect that was enhanced by the emotional visual search strategy. In Experiment 2, whilst trainee police officers displayed a greater threat superiority effect than student controls, both groups benefitted from performing the task under the emotional than semantic visual search strategy. Manipulating situational threat levels (*high* vs *low*) in the experimental instructions had no effect on visual search performance. The current findings provide new support for the language-as-context hypothesis. They are also consistent with a dual-processing account of threat detection involving a verbally mediated route in working memory and the deployment of a visual template developed as a function of training.

Keywords: threat detection, language-as-context, dangerous objects, visual search, policing

Is it dangerous? The role of an emotional visual search strategy and threat-relevant training in the detection of guns and knives

Terrorism has evolved in recent times, with crowded places such as social and retail venues, tourist sites and transport networks (rail, road and airport) remaining an attractive target for international terrorist groups (National Counter Terrorism Security Office, NCTSO, 2017). The threat level for the UK from international terrorism is set by the Joint Terrorism Analysis Centre (JTAC) to provide the public with a broad indication of the likelihood of a terrorist attack, which ranges from LOW (an attack is unlikely) to CRITICAL (an attack is expected imminently). Keeping the general public informed about potential dangers is a widespread communication strategy that can take on many forms. For instance, the Vigipirate system adopted in France relies on colour codes ranging from White (No danger) to Scarlet (Definite threat / prevent major attack) to convey the significance of different levels of terrorist-related activity. Whilst many different factors are taken into account when reaching a judgment on the appropriate threat level, most communication strategies encourage the public to be vigilant of their surroundings, even in instances when the threat level has been lowered from CRITICAL to SEVERE (an attack is highly likely). Thus, engaging in vigilant behaviour, particularly in crowded places is thought to play an essential role in safeguarding the public against potential threats.

In the U.K, some recent initiatives to increase public vigilance levels include Project Griffin and the “See It. Say It. Sorted.” campaign. Delivered by trained police advisors, Project Griffin provides training to local businesses and organizations on how best to reduce and respond to the most likely types of terrorist activities, for instance identifying and responding to suspicious behaviour, or responding to firearms and weapons attacks (NCTSO, 2016). Likewise, for the millions of passengers across England, Scotland and Wales, a new nationwide poster and security announcement campaign has been launched by British

Transport Police to help build a more vigilant rail network via regular reminders to "See It. Say It. Sorted." ("New National Rail security", 2016). This encourages the reporting of any unusual item or activity to members of rail staff and British Transport Police personnel. These are two examples of the many existing programmes aiming to reduce the likelihood of terrorist attacks by relying on individuals' ability to detect threat.

These strategies therefore rely on the assumption that it is possible to increase threat detection by providing explicit verbal instructions to pay attention to dangerous and suspicious behaviours and objects in our environment. Evidence from the experimental psychology laboratory shows that people are generally quite good at detecting threat in a range of different visual contexts (e.g., Blanchette, 2006; Damjanovic, Pinkham, Clarke & Phillips, 2014; Fox et al., 2000; Hansen & Hansen, 1988; Öhman, Flykt & Esteves, 2001; Pinkham, Griffin, Baron, Sasson, & Gur, 2010). However, whether verbal cues can be used to enhance threat detection performance even further is currently unclear. In the present research, we extend the work on threat detection in a novel direction by showing that processing strategies based on emotional rather than semantic verbal cues influence the detection of dangerous objects.

Specific task demands that equip the participant with knowledge about the target's attributes can generate top-down activation prioritizing attention to certain objects in the visual search display. For example, verbally cueing participants on a trial-by-trial basis to attend to the 'orientation' or 'colour' dimension of the visual search display facilitates response times to targets associated with the cue (e.g., Müller, Reimann & Krummenacher, 2003). Likewise, visual search performance can be adjusted as a function of the search strategy prompted by the experimental instructions. Participants who receive instructions to adopt a passive approach in which they allow the discrepant item in the display to "pop" into their mind are faster to detect a target than participants who are instructed to actively search for the discrepant item and to deliberately direct their attention to determine their response (e.g., . *Lleras & von Mühlenen, 2004*; Smilek, Dixon & Merikle, 2006; Smilek, Enns, Eastwood & Merikle, 2006). Together, these results provide evidence that verbal cues can influence visual spatial attention.

Whilst such studies have demonstrated the potential influence of verbal cues on visual search generally, this has rarely been investigated for threat detection specifically. Stimuli that signal threat to one's physical safety such as guns, knives, dangerous animals and angry facial expressions can readily draw attention in a visual search display (e.g., Blanchette, 2006; Damjanovic et al., 2014; Fox et al., 2000; Hansen & Hansen, 1988; Öhman et al., 2001; Pinkham et al., 2010), referred to in the literature as the threat superiority effect (TSE; Fox & Damjanovic, 2006). If verbal cues can shape the perceptual salience of basic object properties in visual search tasks (e.g., Müller et al., 2003; Olivers, 2011; Theeuwes, Reimann, & Mortier, 2007) then actively engaging participants to use an emotional processing strategy may intensify the salience of threatening items and facilitate their detection. Indeed, a growing body of literature shows how words serve to sharpen the visual representation of the stimulus (e.g., Lupyan, 2012; Lupyan & Clark, 2015) and according to the language-as-context hypothesis emotion words in particular can produce a strong impact on emotion perception judgments (see Barrett, 2009; Barrett, Lindquist, & Gendron, 2007; Barrett, Mesquita, & Gendron, 2011; Doyle & Lindquist, 2018; Fugate & Barrett, 2014; Fugate, Gendron, Nakashima & Barrett, 2017; Gendron, Lindquist, Barsalou & Barrett, 2012; Lindquist, 2017; Lindquist & Gendron, 2013; Russell, 1994). For instance, participants primed with an emotion-related word (e.g., *joyous*; compared with a control word) are quicker to select the correct emotion word (e.g., "happy") to label a smiling face (Carroll & Young, 2005, Experiment 2). Emotion words can also affect perceptual memory judgments by biasing participants' responses towards selecting a more intense emotional distractor face (e.g., Fugate et al., 2017), whilst verbal interference at encoding eliminates categorical perception for emotional faces (e.g., Roberson & Davidoff, 2000; Roberson, Damjanovic & Pilling, 2007; Roberson, Damjanovic & Kikutani, 2010).

This language-as-context hypothesis presents an important instance of perceiver-based influence on the task demands underpinning emotion perception. More often than not, in visual search tasks, participants are not explicitly primed with regards to the types of targets (threat/neutral) they will be exposed to; instead they are often instructed to decide whether all the items belong to the same category or whether one is different – often referred to in the literature as discrepant-stimulus search (e.g., Horstmann, 2007). Thus, selecting a suitable search strategy, or attentional set, to locate the target tends to develop implicitly over the course of the experimental trials (e.g., Leber, Kawahara & Gabari, 2009; Öhman, Juth, & Lundqvist, 2010). In the current work, we propose to induce the language-as-context hypothesis by actively encouraging participants to process the targets by focusing on its emotional or semantic properties. Embedding the language-as-context hypothesis in this unique way means that participants' attentional set as they carry out their threat detection task is explicitly primed. This manipulation also enables us to determine whether verbal strategies, such as the ones used in the public safety campaigns aimed to increase vigilance, are likely to be effective at increasing threat detection (e.g., NCTSO, 2016).

Another perceiver-based influence that is likely to play an important role in threat-detection is the emotional state of the observer. For example, individuals with generalized social phobia are faster to detect angry face targets (e.g., Gilboa-Schechtman, Foa, & Amir, 1999) as are individuals with high levels of self-reported trait anxiety (e.g., Byrne & Eysenck, 1995). Patients with schizophrenia display a TSE for non-social threats, such as snakes, but not for social stimuli such as angry faces, relative to healthy controls (e.g., Pinkham et al., 2014). Similarly, and particularly relevant to threat detection, individuals suffering from PTSD show an attentional bias towards threatening stimuli, particularly those related to the trauma (Cisler et al., 2011). Likewise, non-clinical samples exposed to trauma also show an attentional bias towards trauma-related stimuli (Caparos & Blanchette, 2014), whilst individual variation in cognitive reappraisal and emotion regulation strategies play an important role in the time spent attending to threat-relevant information (e.g., Bardeen & Daniel, 2017). Also of interest to threat detection performance, but somewhat distinct from threat-based visual search tasks is the shooter bias paradigm (Baumann & DeSteno, 2010). Here, participants view several different urban and suburban scenes (e.g., park, train station, etc.,) and have to decide whether a target individual is holding a gun or a neutral object (e.g., camera, wallet, etc.,) by means of a key press (Baumann & DeSteno, 2010) or by pulling the trigger (or refraining from doing so on neutral object trials) on a realistic, wireless gun controller (e.g., Wormwood, Lynn, Feldman Barrett & Quigley, 2016). Participants who were instructed to write about an angry memory prior to participating in the shooter bias paradigm were more likely to misidentify a neutral object as a gun than vice versa (Baumann & DeSteno, 2010), while participants who were asked to write about their daily routine or about a happy or other negative event (e.g., sadness or disgust) did not demonstrate a significant difference in the types of misidentification errors made. Thus, perceiving the presence or absence of a gun is influenced by the specific emotional state of the observer; anger increases false alarms in threat detection, whilst other negative emotions do not.

Another perceiver-based dimension that may affect threat detection is training and expertise (e.g., Damjanovic et al., 2014). Our past experiences, stored as memories, build expectations and forecast where interesting or relevant events will unfold. Attentional orienting based on long-term memory is essential for targeting behaviorally relevant objects or events embedded in complex environments and therefore for optimizing our perception and action (e.g., Summerfield, Lepsien, Gitelman, Mesulam & Nobre, 2006). For instance, experienced crowd control officers showed enhanced detection of threatening faces over their trainee and control counterparts (Damjanovic et al., 2014), whilst searching for dangerous weapons or a visual target preceded by a threatening verbal cue is improved in both trainees and experienced officers when both groups are encouraged to adopt an emotional processing strategy ([BLINDED]; Williot & Blanchette, 2018). Together, these findings illustrate how threat detection can improve as a function of expertise and how goal-directed factors can help policing professionals detect threatening objects.

In the present research, we investigate these three perceiver-based influences on threat detection using the visual search task: the language-as-context hypothesis, the emotional state of the observer (via self-reported measures of anxiety, paranoia, trauma and cognitive emotion regulation) and threat-relevant training. Given that embedding emotional processing strategies has been shown to enhance threat detection within a policing context ([BLINDED]), it is currently unclear whether the benefits of this strategy can also extend to individuals with no policing experience. This is an important issue to address given that public awareness campaigns are developed to be as accessible as possible, irrespective of the occupational background of the observer. As such, Experiment 1, builds on the threat detection task designed by Blanchette (2006) and more recently [BLINDED] by recruiting and testing University student participants without any formal threat detection training. Participants will be required to make same-different judgements in response to viewing a 3 x 3 matrix display consisting of non-social stimuli. On target present (i.e., 'different') trials, participants will be presented with a negatively valenced object (i.e., a gun or a knife) or a valence-neutral object (i.e., *watering gun or pen*) against a constant background of valence-neutral distractors (i.e., *shelf brackets or spoons*). In one experimental block, each matrix will be followed by the question "is it dangerous?" and in another, it will be followed by the question "is it an object?" This question refers to the target in the matrix just presented. Thus, for each block of experimental trials participants will either be primed with an emotional (i.e., "is it dangerous?") or a semantic cue (i.e., "is it an object?") as they perform the visual search task. In line with [BLINDED'S] findings, we hypothesized that participants would display an overall TSE, yielding significantly faster response times on 'different' trials containing a gun or a knife than a *watering gun or pen*. The language-as-context hypothesis would predict that encouraging participants to adopt an emotional processing strategy by responding to an emotional verbal cue (i.e., "is it dangerous?") would enhance the perceptual salience of threat-relevant targets, resulting in a larger TSE than responding to a semantic verbal cue (i.e., "is it an object?).

In Experiment 2, we apply our threat detection task to the area of threat-relevant experience and training. Specifically, we recruited a group of police trainees who were enrolled on the Initial Police Learning and Development Programme (IPLDP). In England and Wales, IPLDP students are continuously trained and assessed to develop their threat awareness skills in line with the National Decision Model (College of Policing, 2013). This involves learning not only how to identify weapons such as knives and guns, but also how to increase their vigilance for seemingly neutral objects such as keys, coins and credit cards, which can be readily converted into a stabbing, throwing or slashing weapon by the assailant. Thus, IPLDP students' experiences of learning on the job to manage conflict in a policing context is likely to equip them with richer representations of the affective properties of visual objects in their environment (e.g., Barrett, 2017; Lebrecht, Bar, Barrett & Tarr, 2012) relative to students without specialized and accredited threat training experience. In the current work, we compared threat detection performance of our police trainees with a control group consisting of students without IPLDP training, recruited from standard University programmes. We predicted that the police trainee group would display a larger TSE than the control group.

To ground our visual search task to a policing context even further, in Experiment 2 both groups were instructed to approach their visual search performance under different situational threat level instructions adapted from the National Decision Model (College of Policing, 2013). If both groups are able to maintain these broader instructions in working memory (e.g., Smilek et al., 2006; Smilek, Enns et al., 2006) and this subsequently impacts on task performance we predict that heightened levels of situational threat would result in a larger threat superiority effect relative to reduced levels of situational threat. This important manipulation in the design would enable us to understand some of the potential constraints of these strategic influences on working memory in terms of whether they can operate at both a broad (i.e., situational threat level) and proximal level (i.e., ‘is it dangerous?’) of the task at hand (see also Greenaway, Kalokerinos & Williams, 2018 for a detailed discussion on the role of situational factors in emotion processes). Such comparisons and their potential interactions will not only make an important theoretical advance on the role of language mediated top-down control on visual search (e.g., Huettig, Olivers & Hartsuiker, 2011; Olivers, 2011), but also raise important practical insights into the communicative effectiveness of public safeguarding campaigns.

Finally, although there is strong evidence in the literature that the threat superiority effect correlates with a range of self-report measures, such that negative affective states like anxiety correlate with enhanced threat detection (e.g., Byrne & Eysenck, 1995), it is currently unclear whether such correlations extend to stimuli of a non-social nature or to visual search tasks that actively manipulate the type of information processing strategies available to participants. Indeed, recent research from a policing context hints at very little modulation if at all between self-reported levels of anxiety, depression and trauma in the threat detection of dangerous objects [BLINDED]. Our final aim was to establish the consistency of these results in both controls and police trainees and under different types of processing strategies.

1 Experiment 1

1.1 Method

1.1.1 Ethics statement

The participants provided written consent to procedures approved by the ethics committee of the University's Psychology Department and were compensated £10 for their participation.

1.1.2 Participants

A total of 29 participants were recruited for the study, from which 24 contributed data to the analysis (see Design & Analysis section for exclusion details). The participants (female = 22, male = 2; Mdn age = 20, Min = 18; Max =55) were students recruited from the University campus. Table 1 shows the questionnaire data for those participants who contributed data.

INSERT TABLE 1 ABOUT HERE

1.1.3 Stimuli and apparatus

Visual search task presentation and data collection were conducted with an Intel Core PC desktop computer with a 2.93-GHz processor on a standard screen (34.0 cm X 27.2 cm). A refresh rate of 60Hz and a resolution of 640 X 480 were used. E-prime software delivered stimuli and recorded responses and reaction times (RTs). Manual responses to the visual search task were collected from designated response keys on the computer's keyboard.

We used 102 different matrices of nine images (three lines * three columns). It was the same matrices used by [BLINDED]. A matrix could contain nine different images of the same category (distractors) or eight different distractors of the same category and one image of a target taken from a different category. Distractors were always neutral (*shelf brackets, spoons*) and targets could be threatening (guns, knives) or neutral (*watering guns, pens*). We kept distractors constant across the different targets because we wanted to be able to see the impact of the type of target (threatening vs neutral) exclusively, not the impact of distractors type (see Figure 1). The distractors and target combinations was: gun plus shelf brackets (e.g., 18 trials - each target appeared twice in each of the nine positions in the matrix); watering gun plus shelf brackets; knife plus spoons; pen plus spoons. We used four exemplars of targets in nine different positions presented two times (4*9*2), so there were 72 target-present trials per block and 30 trials without a target. All targets (guns, knives, *watering guns, pens*) were presented twice at the same location, randomly in one of the nine possible locations, each with different distractors. All images were presented in black and white and were controlled for luminosity and contrast with the SHINE Toolbox with Matlab (Willenbockel et al., 2010). All stimuli had the same orientation in each matrix because we did not want participants to be faster to detect a target due to a possible affordance (e.g., Belardinelli, Herbort, & Butz, 2015; Sartori, Straulino, & Castiello, 2011).

INSERT FIGURE 1 ABOUT HERE

1.1.4 Procedure

Participants were tested in small groups. Participants first signed the informed consent and completed the state anxiety scale (STAI-A; Spielberger, Gorsuch, & Lusthene, 1983). They then performed the visual search task. Participants had to place their head on a chin rest located 60 cm from the screen.

Participants were instructed to look at the fixation point (a dot) in the center of the screen at the beginning of each trial (see Figure 2). The fixation point disappeared after 500ms, and was followed by a matrix. Participants' task was to quickly detect if the nine pictures belonged to the same category (by pressing 'A' key) or if there was one picture (the target) belonging to a different category (by pressing 'L' key) on the computer's keyboard. The matrix disappeared when participants made a response. A question was then presented in relation to the target. This question could be semantic (Is it an object?) or emotional (Is it dangerous?). Participants answered 'yes' by pressing the 'A' key or 'no' by pressing the 'L' key. Responses keys were counterbalanced across participants to prevent the possibility of motor response effects. The question was the same for all trials within a block. Participants did not have to answer the question when the matrix did not include a target, they simply skipped the question.

The aim of asking participants to answer a question concerning the target was to encourage processing of the target based on a more emotional dimension or on a semantic dimension. Because the same question was repeated all through a block, participants knew before the presentation of the stimuli which question they would be asked concerning the target. The knowledge of the question in advance should create expectations to process the matrix in line with this question, even if the question is only provided after the target has been presented. Participants were asked to maintain high accuracy on both the target detection task and in answering the semantic/affective question.

The visual search task was presented in two blocks of 102 trials each presenting one of the matrices described previously, in a random order. The order of the block inducing a semantic processing strategy and the one inducing an emotional processing strategy was counterbalanced across participants. This was preceded by a practice block of ten trials with stimuli not included in experimental blocks, using the semantic processing strategy.

Immediately after the visual search task ended, participants were provided with the state component of the STAI as a post-test measure of state anxiety to complete, followed by the trait anxiety measure (STAI-A, STAI-B; Spielberger et al., 1983), the cognitive emotional regulation questionnaire (Garnefski, Kraaij, & Spinhoven, 2001), the Post-Traumatic Stress Disorder scale (PTSD Checklist; Weathers, Litz, & Herman, 1993) and finally the paranoia scale (Fenigstein & Vanable, 1992).

INSERT FIGURE 2 ABOUT HERE

1.1.5 Questionnaires

State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983): This is one of the most long-standing and commonly used self-rating scales for measuring the severity of anxiety. The questionnaire is divided into two, twenty-item subscales designed to measure the intensity of how much anxiety a person feels “right now, at this moment” (STAI-State or STAI-S subscale) and the frequency of how a person “generally feels” anxious (STAI-Trait or STAI-T subscale). Respondents are asked to rate each item on a 4-point Likert-type scale, ranging from 1 (almost never) to 4 (almost always). The total score ranges from 20 to 80, with higher scores indicating greater anxiety. The STAI has good psychometric properties, including high reported internal consistency (trait = .90 - .91; state = .86 - .94), adequate retest reliability and appropriate convergent validity (Spielberger et al., 1983).

- *Cognitive Emotion Regulation Questionnaire* (CERQ; Garnefski, Kraaij & Spinhoven, 2002) is a 36-item self-report measure developed to identify cognitive strategies for emotional regulation that someone uses after having experienced negative events or situations (e.g., I feel that I am the one to blame for it). The CERQ distinguishes nine different strategies, of which, independently from one another, clinical psychological literature has established their association with psychopathology. Participants are asked to respond to each item using a 5-point scale ranging from 1 (almost never) to 5 (almost always). Individual subscale scores are obtained by summing up the scores belonging to particular subscale or cognitive emotion regulation strategy (from 4 to 20). The CERQ has good psychometric properties, including high reported internal consistency (α = .70-80), adequate retest reliability (α = .48 - .65) and appropriate discriminative properties (Garnefski et al., 2002).

- *Post-Traumatic Stress Disorder scale* (PTSD Checklist; Weathers, Litz, & Herman, 1993): This scale consists of 17 questions (e.g. How much have you been bothered by repeated, disturbing dreams of a stressful experience from the past?) that assess symptoms of post-traumatic stress after a highly emotional experience. The presence of each symptom is assessed on a scale ranging from 1 (not at all) to 5 (extremely). This questionnaire is based on categories of DSM-IV symptoms (reliving, avoidance, autonomic hyperactivity) with good psychometric properties (Blanchard, Jones-Alexander, Buckley, & Forneris, 1996). Diagnosis of post-traumatic disorder can be determined when the total score is above 50 (with a minimum of 17 and a possible maximum of 85).

- *The Paranoia Scale* (PS) is a 20-item self-report measure of paranoid ideation that was originally derived from the Minnesota Multiphasic Personality Inventory (MMPI). Participants are asked to respond to each item using a 5-point scale ranging from 1 (not at all applicable to me) to 5 (extremely applicable to me). Scores range from 20 to 100 with higher scores indicating higher levels of paranoia. The PS has good psychometric properties, including high reported internal consistency ($\alpha = .84$), adequate retest reliability ($\alpha = .70$) and appropriate convergent and discriminant validity (Fenigstein & Vanable, 1992).

1.1.1 Design & Analysis

Of the 29 participants, one participant's file was corrupted and no data was available. Three participants were excluded from analyses because they failed to reach a minimum accuracy of 70% in their answers to the questions and one participant failed to reach a minimum accuracy of 70% in target detection. We used this threshold to ensure that participants were performing both tasks sufficiently well.

The main behavioral dependent measure was participants' reaction times in target detection. We wanted to see if threatening targets were detected faster than neutral targets, when both were presented among neutral distractors. We considered average mean per condition, including only correct answers (97%). Reaction times lower than 250ms were excluded as well as those greater than two standard deviations above the participant's individual mean, to reduce the influence of outliers (Mogg, Holmes, Garner, & Bradley, 2008). Threat detection performance was measured using RTs recorded from the onset of each matrix to participant response on discrepant trials. We performed an analysis of variance (ANOVA) to determine the impact of target type (threatening or neutral) and *verbal* processing strategy (emotional or semantic). We also conducted correlational analyses (Pearson's or Spearman's rank) to investigate the link between participants' emotional state and reaction times for each processing strategy separately. We also calculated the change in state anxiety (before and after the experiment) and examined its correlation with threat detection. For the correlational analyses, we applied the Bonferroni adjustment to the alpha level for multiple comparisons, resulting in a new alpha level of $p < .01$ for each processing strategy. For all other analyses, the alpha level was set at $p < .05$.

1.2 Results and Discussion

An ANOVA conducted on reaction times (RT) showed a significant main effect of target type $F(1,23) = 59.98$, $p < .001$, $\eta^2_p = 0.72$, consistent with a TSE showing faster responses to guns and knives ($M = 1075.08$; $SE = 39.86$) than to *watering guns and pens* ($M = 1208.56$; $SE = 46.82$). The differences in response times between emotional ($M = 1167.22$; $SE = 55.26$) and semantic ($M = 1116.42$, $SE = 39.29$) processing strategies was not significant overall, $F(1,23) = 1.34$, $p > .05$, $\eta^2_p = 0.06$. Importantly, the interaction between target type and *verbal* processing strategy was significant, $F(1,23) = 12.15$, $p < .01$, $\eta^2_p = .35$. Post-hoc analyses showed that when the processing strategy was emotional, reaction times were faster when the target was threatening compared to neutral $t(23) = -6.82$, $p < .001$, $r = 0.82$. When the processing strategy was semantic, reaction times were also faster when the target was threatening compared to when it was neutral $t(23) = -2.92$, $p < .01$, $r = 0.52$ (see Figure 3). A threat superiority score was established, for each processing strategy, by subtracting threatening target RT from neutral target RT. A positive score represents faster detection of threat and a negative score represents longer RT to threat. The threat superiority score was greater when the induced *verbal* processing strategy was emotional ($M = 202.18$; $SE = 29.66$), compared to semantic ($M = 64.78$; $SE = 22.17$), $t(23) = 3.49$, $p < .01$, $r = 0.59$.

INSERT FIGURE 3 ABOUT HERE

1.2.1 Correlations

None of the correlations reached significance at $p < .01$ (see Table 2).

INSERT TABLE 2 ABOUT HERE

1.2.2 Trait anxiety

Comparison of the group's mean trait anxiety score with associated norms (Spielberger et al., 1983) revealed significantly elevated levels of self-reported anxiety in this sample of participants[norm M=39.35, $t(23) = 2.33$, $p < .05$, $r = .30$].

1.2.3 Changes in State Anxiety

Although participants' state anxiety increased slightly upon completion of the task by approximately 2.5 points (Min = -20; Max = 15), a one-sample Wilcoxon signed-rank test indicated that the median change in anxiety was not significantly different from 0, $z = 1.19$, $p > .05$, $r = .24$.

These findings demonstrate that the TSE previously reported with dangerous objects (i.e., Blanchette, 2006) can be affected by verbal instructions embedded over the course of the visual search task. We demonstrate how actively engaging with an emotional processing strategy can enhance the detection of dangerous objects, thus replicating [BLINDED'S] recent findings and illustrate that these benefits can also extend to individuals outside of the policing profession. This pattern of results also extends the language-as-context hypothesis to visual search processing (e.g., Gendron et al., 2012). Furthermore, the emotional state of the observer did not appear to play a role in threat detection for dangerous objects – a pattern that has been previously reported by [BLINDED]. In Experiment 2, we sought to examine the influence of threat-relevant experience and training on the visual search for dangerous objects by comparing the TSE in a group of trainee police officers (i.e., police trainee group) with another group of student learners without such specialized training and learning experience (i.e., control group). We also investigated the influence of verbal instructions on working memory at a broader vs proximal level. This was operationalized by instructing participants to perform the visual search task under two different situational threat level instructions adapted from the National Decision Model (College of Policing, 2013). The rationale for including this manipulation was to examine whether the addition of a situational threat context would differentially impact the effectiveness on the emotional processing strategy in particular. Thus, Experiment 2 was identical to Experiment 1 in all ways except as noted below.

2 Experiment 2

2.1 Method

2.1.1 Ethics statement

The participants provided written consent to procedures approved by the ethics committee of the University's Psychology Department and were compensated £10 for their participation.

2.1.2 Participants

A total of 63 participants were recruited for the study, from which 51 contributed data to the analysis (see Design & Analysis section for exclusion details). The control group (female = 20, male = 1; Mdn age = 19, Min = 18; Max = 36) was composed of students recruited from the University campus (see Table 3). The police trainee group (female = 8, male = 22; Mdn age = 27, Min = 22; Max = 41) was recruited from police recruitment and assessment stations in England. At the time of testing, the police trainees were approximately 4 months into their 2-year Initial Police Learning and Development Programme (IPLDP) and had received training on how to conduct safe interactions with members of their community, first aid training, and officer health and safety training.

INSERT TABLE 3 ABOUT HERE

Participants in the control group were significantly younger than the police trainees, $U = 28$, $z = -5.53$, $p < .05$, $r = -0.77$. Participants in the control group were significantly more anxious, as measured by the state anxiety scale, at the beginning of the experiment than individuals in the police trainee group $t(49) = -2.42$, $p < .05$, $r = 0.33$; and similarly at the end of the experiment, $t(49) = -3.15$, $p < .01$, $r = 0.41$. The control group also showed significantly higher levels of trait anxiety, compared to the group of police trainees $t(49) = -4.22$, $p < .001$, $r = 0.52$. The control group had a significantly higher average score on the PCL scale than the police trainees $U = 170.50$, $z = -2.77$, $p < .01$, $r = -0.39$, and on the paranoia scale $U = 185.50$, $z = -2.48$, $p < .05$, $r = -0.34$. Emotion regulation, as measured by the CERQ, did not differ between the groups, $t(49) = 1.85$, $p > .05$, $r = 0.26$.

2.1.3 Stimuli, apparatus, procedure & questionnaires

We used the same stimuli, apparatus, procedure and questionnaires as in Experiment 1. The only difference was that we manipulated the *situational threat level*. In one block participants were instructed to process stimuli under *high* threat levels (204 trials). In the other, participants were asked to process stimuli under *low* threat levels (204 trials). These instructions were adapted from the threat awareness training protocol provided to trainee officers over the course of their programme. *High threat levels* corresponded to the following instructions: “The fight is on! Decisive and immediate action! Recognizing attack rituals and set-ups helps one to avoid this level”. *Low threat levels* corresponded to the following instructions: “You are alert and aware but also calm and relaxed. You are alert to the surroundings (and environment) and to the people who occupy it and to their body language. You are alert, not paranoid. In this state it is difficult for someone to surprise you.” The order of the blocks was counterbalanced across participants. They were informed about the *situational threat level* after the practice block.

In total, therefore, there were an equal number (102; including 72 with target and 30 without) of trials with a semantic question under *high threat* instructions, trials with an emotional question under *high threat* instructions, trials with a semantic question under *low threat* instructions, and trials with an emotional question under *low threat* instructions.

2.1.4 Design & Analysis

Of the 63 participants, one participant's file from the control group was corrupted and no data was available. Eight participants were excluded from analyses because they failed to reach a minimum accuracy of 70% (four trainee officers and four controls) in their answers to the questions and four participants from the trainee officer group failed to reach a minimum accuracy of 70% in target detection. As before, the main behavioral dependent measure was participants' reaction times in target detection. We considered average mean per condition, including only correct answers (95%). Reaction times lower than 250ms were excluded as well as those greater than two standard deviations above the participant's individual mean (Mogg, Holmes, Garner, & Bradley, 2008). The same analyses as used in Experiment 1 were conducted here with the exception of ANOVA: group (control, police trainees), target type (threatening, neutral), *verbal* processing strategy (emotional, semantic) and situational threat level (*high, low*), with repeated measures on the last three factors.

2.2 Results and Discussion

The analysis of variance conducted on reaction times (RT) revealed a significant two way interaction between target type (threatening vs. neutral) and *verbal* processing strategy (emotional vs. semantic) $F(1,49) = 32.19$, $p < .001$, $\eta^2_p = .40$. Post-hoc analyses showed that when the processing strategy was emotional, reaction times were faster when the target was threatening compared to neutral $t(50) = -11.11$, $p < .001$, $r = 0.84$. When the processing strategy was semantic, reaction times were also faster when the target was threatening compared to when it was neutral $t(50) = -6.55$, $p < .001$, $r = 0.68$ (see Figure 4). The interaction stems from the fact that the threat superiority score was greater when the induced processing strategy was emotional ($M = 194.68$; $SE = 17.52$), compared to semantic ($M = 101.22$; $SE = 15.45$), $t(50) = 5.81$, $p < .001$, $r = 0.63$.

INSERT FIGURE 4 ABOUT HERE

The analysis also showed a two way interaction between target type (threatening vs. neutral) and group (controls vs. trainees) $F(1,49) = 6.64$, $p = .013$, $\eta^2_p = .12$. Post-hoc analyses showed RTs were faster when the target was threatening, compared to neutral, in both the police trainee group $t(29) = -9.12$, $p < .001$, $r = .86$, and the control group, $t(20) = -5.84$, $p < .001$, $r = 0.48$ (see Figure 5). The threat superiority score was greater for the police trainees ($M = 177.42$; $SE = 19.46$), compared to the control group ($M = 105.85$; $SE = 18.12$), $t(49) = 2.58$, $p < .05$, $r = .35$.

INSERT FIGURE 5 ABOUT HERE

The two way interaction between processing strategy (emotional vs. semantic) and group (controls vs. trainees) approached significance $F(1,49) = 4.01$, $p = .051$, $\eta^2_p = .08$. The analysis also showed a main effect of target type $F(1,49) = 103.92$, $p < .001$, $\eta^2_p = 0.68$, replicating the TSE with faster responses to guns and knives (*M* = 985.71; *SE* = 31.06) than to *watering guns and pens* (*M* = 1127.34; *SE* = 36.40). There was also a significant main effect of *verbal* processing strategy $F(1,49) = 10.23$, $p = .002$, $\eta^2_p = 0.17$, with faster response times to the semantic (*M* = 1020.97; *SE* = 34.11) than the emotional question (*M* = 1092.07; *SE* = 35.73). There was no significant main effect of group, $F(1,49) = 0.23$, $p > .05$, $\eta^2_p = 0.01$, nor situational threat *level*, $F(1,49) = 1.79$, $p > .05$, $\eta^2_p = 0.04$. The situational threat *level* did not interact significantly with any of the variables ($F < 1$).

2.2.1 Correlations

After applying the Bonferroni adjustment for multiple comparisons, the only significant correlation to emerge from the analysis was between self-reported levels of post-traumatic stress after a highly emotional experience and threat detection with a semantic processing strategy with *low* levels of situational threat, $r_s = -.36$, $p < .01$ (see Table 4)

INSERT TABLE 4 ABOUT HERE

2.2.2 Change in State Anxiety

Levels of state anxiety reported by the control group increased by approximately 5 points (Min = -12; Max = 11), however a one-sample Wilcoxon signed-rank test indicated that the median was not significantly different from 0, $z = 1.08$, $p > .05$, $r = .24$. Levels of state anxiety reported by the trainee officers decreased by approximately 2 points (Min = -12; Max = 20), however a one-sample Wilcoxon signed-rank test indicated that this decrease was not significantly different from 0, $z = -1.71$, $p > .05$, $r = .-31$. The difference between groups in these changes in state anxiety approached significance, $U = 215$, $z = -1.92$, $p = .055$, $r = -.27$.

2.2.3 Trait anxiety

Comparison of the control group's mean trait anxiety score was significantly higher than associated norms [norm M=39.35, $t(20) = 3.29$, $p < .05$, $r = .77$]. In contrast, the trainee group's mean trait anxiety score was significantly lower than associated norms [norm M= 38.84, $t(29) = 2.24$, $p < .05$, $r = .38$].

Once again, the findings demonstrate strategic influences on target detection performance such that when participants performed the task with an emotional processing strategy they were faster to detect dangerous objects than when they performed the task with a semantic processing strategy. In line with predictions, the trainee police officers showed a greater TSE than the control participants (see Damjanovic et al., 2014). Manipulating situational threat levels via the experimental instructions did not influence target detection performance in any way. Furthermore, the only time the emotional state of the observer played a role in threat detection was in the *low* threat *level* context with semantic processing instructions. Overall these findings provide further support for the language-as-context hypothesis (e.g., Gendron et al., 2012) and replicate the work of [BLINDED]. Moreover, whilst trainee police officers showed a greater TSE overall, both groups of participants equally benefited from approaching the visual search task with an emotional processing strategy.

3 General Discussion

The results from the two experiments reported in this article demonstrate the effect of verbal instructions on visual search for dangerous objects. Specifically, verbal instructions that actively engage participants to adopt an emotional processing strategy facilitates the detection of guns and knives than verbal instructions that focus on a semantic processing strategy. This pattern of results supports the recent work of [BLINDED] and provides new evidence in support of the language-as-context hypothesis by demonstrating how conceptual processing alters the detection of visual objects in a visual search task (see Barrett, 2009; Barrett, Lindquist, & Gendron, 2007; Barrett, Mesquita, & Gendron, 2011; Doyle & Lindquist, 2018; Fugate & Barrett, 2014; Fugate et al., 2017; Gendron, Lindquist, Barsalou & Barrett, 2012; Lindquist, 2017; Lindquist & Gendron, 2013; Russell, 1994).

In both experiments, participants were significantly faster to detect the dangerous than the neutral object, demonstrating a TSE in line with previous visual search tasks with non-social objects (Blanchette, 2006; [BLINDED]). However, this TSE can be enhanced further but only when working memory is primed by proximal instructions encouraging an emotional processing strategy - priming working memory with broader instructions aimed at identifying situational threat (e.g., *high vs low*) had no impact on performance. Participants' threat detection was just as efficient in response to the emotional processing strategy when it was encountered under *high* threat search levels as when encountered under *low* threat search levels. It appears that active strategies can go on to have a beneficial impact on target detection but only when regularly primed (cf. *Lleras & von Mühlenen, 2004;* Smilek, Dixon & Merikle, 2006; Smilek, Enns, Eastwood & Merikle, 2006). A tentative implication of these findings is that the language-as-context hypothesis may operate at a local level within the demands of a given task and independently from the wider external cues provided by the situational context (Greenaway et al., 2018). We operationalized the threat level alerts in our current procedure to closely resemble those encountered in a policing context, thus future research designs which manipulate both types of *verbal cues* with equal frequency may help to establish the functional characteristics of the language-as-context hypothesis in more detail. Nevertheless, some important practical implications are raised by these results: safeguarding campaigns that focus on general situational threat levels may not be as effective in increasing public vigilance levels relative to strategies that encourage the observer to focus on the dangerous aspects of their surroundings in a more active way.

Threat-relevant experience and training proved to be another important perceiver-based influence on threat detection performance. Whilst both groups of participants benefitted from being cued with the emotional processing strategy, the trainee police officers displayed a significantly greater TSE overall than the controls. In visual search tasks with social stimuli, trainee police officers often do not fare much better in their threat detection abilities relative to the control group (see Damjanovic et al., 2014), but for non-social stimuli as used in the current task, trainee police officers displayed an attentional advantage by approximately 70ms over the control group. Thus, different categories of visual search items may produce quantitative and qualitative differences in information processing as a function of expertise or personal relevance (e.g., Godwin et al., 2010; Hershler & Hochstein, 2009; Malinowski & Hübner, 2001; Pinkham et al., 2014).

Another perceiver-based influence on threat detection performance that was investigated in the current study was the emotional state of the observer. We used self-report measures previously shown to correlate with threat detection performance (e.g., Bardeen & Daniel, 2017; Byrne & Eysenck, 1995; Cisler et al, 2011; Damjanovic et al., 2014; Pinkham et al., 2014). By and large, we did not find evidence of a link between self-reported questionnaires and the TSE, a pattern consistent with the findings reported by [BLINDED]. This suggests that guns and knives may elicit a specific type of emotional state that is not readily captured by the properties of more global measures relating to anxiety, paranoia, trauma and cognitive emotion regulation (Goodwin, Willson & Gaines, 2005*; Zinchenko et al., 2017*). Given our relatively small samples, we should be cautious about interpreting these null effects. Nevertheless, when considering group-based differences in trait anxiety levels and their deviation from associated norms, the control group exhibited significantly higher scores than the trainee police officers and displayed significantly elevated anxiety from normative data. In contrast, the trainee police officers showed significantly lower levels of trait anxiety from normative scores. In the context of these group differences in trait anxiety, it is interesting to note that the trainee police officers showed an increased threat superiority effect despite showing lower levels of anxiety. This particular pattern of results suggests that self-reported anxiety may play a secondary role to the cognitive enhancements afforded by threat-relevant training or processing strategies ([BLINDED]; Damjanovic et al., 2014).

The present results can also be viewed within the context of theoretical frameworks that take into account how working memory may serve as the central interface between language and an attentional orienting response to a visual object (Huettig, Olivers & Hartsuiker, 2011). During the presentation of a visual search display, visual form representations become bound to specific spatio-temporal indices within working memory. Given sufficient time, associated semantic and phonological codes from long-term memory cascades through to the existing visuospatial working memory representations, thus creating a hub of linguist and visuospatial activity. Given that the TSE with dangerous objects occurs even without the systematic manipulation of verbal cues (e.g., Blanchette, 2006), introducing them into the visual search task effectively acts as boosting mechanism for this cascading process resulting in a larger TSE under the "is it dangerous" processing condition for both groups of participants. The addition of this boosting mechanism, points towards a dual-processing account of enhanced threat detection in a visual search testing context. One route is largely verbally mediated (e.g., “is it dangerous?”) and operates by enhancing the representation of the threatening object in working memory. The other route consists of the deployment of a robust, visually guided template that rapidly matches the dangerous item in the search display to the representations stored within the long-term semantic memory system (e.g., Baddeley, 1997; Damjanovic et al., 2014; Jones, 1988). Over the course of their continuing professional development, trainee police officers may develop representations that are more routinely situated not only in terms of general knowledge properties (e.g., physical and semantic attributes), but also in terms of events that happen here and now, or there and then (e.g., Huettig et al., 2011; Kahneman, Treisman & Gibbs, 1992; Pylyshyn, 2001). These contextually richer experiences may support the development of a “guiding” template of guns and knives for the deployment of attentional orienting (e.g., Damjanovic et al., 2014; Jackson & Raymond, 2008).

In interpreting these results, some limitations regarding the nature of the group-based differences must be considered. Specifically, the quasi-experimental nature of the design makes it difficult to differentiate whether the group differences observed in the current study could be explained in terms of trait characteristics or whether enhanced threat perception performance can become readily tuned as a consequence of one’s threat-relevant vocational training (e.g., Damjanovic et al., 2014; Paulus et al., 2010). Future experimental designs that incorporate both cross-sectional and longitudinal elements will help to establish whether the template route becomes even more finally tuned as function of training and operational field-work experience (Damjanovic et al., 2014). *A further limitation regarding the potential mismatch in task load between the two verbal processing strategies would also need to be addressed in future designs. As all items in the visual search display were objects, this means that under the semantic processing strategy the correct answer was always “yes”, whilst for* *the emotion processing strategy it would either be "yes" or "no". However, main effect analyses of the verbal processing strategies did not support a consistent effect of these surface level differences on reaction time performance. Nevertheless, in future studies, there could be a more exhaustive consideration of such surface level characteristics.*

In closing, our results show that alerting people to decide whether an object is dangerous not only improves their ability to detect images of guns and knives, but is also a stable verbal cue that is unaffected by the wider situational threat context or the emotional state of the participant. Additionally, the presence of a larger threat superiority effect in our trainee officers, helps to provide some reassurances that front line staff can use their real world training to help safe guard the public against visible dangers. These findings underscore the importance of prior knowledge and training on threat detection performance and reinforce the need for intervention programmes to emphasize the use of linguistic cues to sharpen our awareness of potential dangers in our environment.

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Table 1. *Participant characteristics (N = 24).*

Measure	*Mean*	SD
Trait-STAI	44.33	10.50
State-STAI (pre-test)	40.58	10.47
State-STAI (post-test)	41.96	12.66
PCL	42.04	12.69
Paranoia	42.46	9.45
CERQ	100.25	16.85

Table 2. *Pearson's correlations between the threat superiority effect (TSE) for emotional and semantic visual search strategies and change in STAI-State anxiety, STAI-Trait anxiety, Paranoia Scale, Post-traumatic Stress Disorder Scale (PCL) and Cognitive Emotion Regulation Questionnaire (CERQ).*

Measure	Change in STAI-S[1]	STAI trait anxiety	Paranoia scale	PCL	CERQ
TSE_Emotional Processing Strategy	-0.35	-0.34	0.03	-0.08	-0.03
TSE_Semantic Processing Strategy	0.28	-0.11	0.12	0.04	0.13

Table 3. *Participant characteristics.*

	Controls (*n* = 21)		Trainee officers (*n* = 30)	
Measure	*Mean*	SD	*Mean*	SD
State-STAI (pre-test)	41.43	8.94	35.83	7.53
Trait-STAI	46.38	9.80	35.13	9.05
State-STAI (post-test)	43.48	9.62	34.73	9.86
CERQ	91.81	10.00	98.70	14.82
	Median	Min-max	Median	Min-max
PCL	37.00	20-72	25.50	17-65
Paranoia	48.00	29-70	34.50	20-67

Table 4. *Spearman rho correlations between the threat superiority effect (TSE) for emotional and semantic visual search strategies with high and low situational threat levels and change in STAI-State anxiety, STAI-Trait anxiety, Paranoia Scale, Post-traumatic Stress Disorder Scale (PCL) and Cognitive Emotion Regulation Questionnaire (CERQ).*

Measure	Change in STAI-S	STAI trait anxiety	Paranoia scale	PCL	CERQ
TSE_*High*_Emotional Processing Strategy	0.19	-0.19	-0.08	-0.20	0.09
TSE_*High*_Semantic Processing Strategy	0.27	-0.09	-0.02	-0.15	0.20
TSE_*Low*_Emotional Processing Strategy	0.10	0.05	0.15	-0.05	0.25
TSE_*Low*_Semantic Processing Strategy	0.01	-0.28	-0.21	-0.36	0.03

Figure captions

Figure 1. Presentation of stimuli in matrix. a) and b) A threatening target (gun, knife) or a neutral target (watering gun, pen) could be presented as a target with the same kind of distractors (shelf brackets or spoons) in a matrix. c) All the stimuli could be presented as one kind of distractor without target.

Figure 2. Trial structure. A trial started with a fixation point presented for 500ms. The matrix of nine images (with threatening target as in a), neutral target as in b) or no target as in c) then appeared until the participant answered about the presence of a target or for a maximum of 4 seconds. Thereafter, the question about the target appeared until the participant answered or for a maximum of 4 seconds. The question was either semantic (Is it an object?) or emotional (Is it dangerous?) as in the example here and was constant within a block and known by the participant before to start a block.

Figure 3. Reaction time to detect the target according to target type and processing strategy. We applied a correction based on the standard error (+/- 1 SE) to properly represent the intra-subject variability (Cousineau & O'Brien, 2014). *$p < .05$.

Figure 4. Reaction time to detect the target according to target type and processing strategy *combined across the* police trainees and control group. We applied a correction based on the standard error (+/- 1 SE) to properly represent the intra-subject variability (Cousineau & O'Brien, 2014). *$p < .05$.

Figure 5. Reaction time for each group according to the target type. We applied a correction based on the standard error (+/- 1 SE) to properly represent the intra-subject variability (Cousineau & O'Brien, 2014). *$p < .05$.

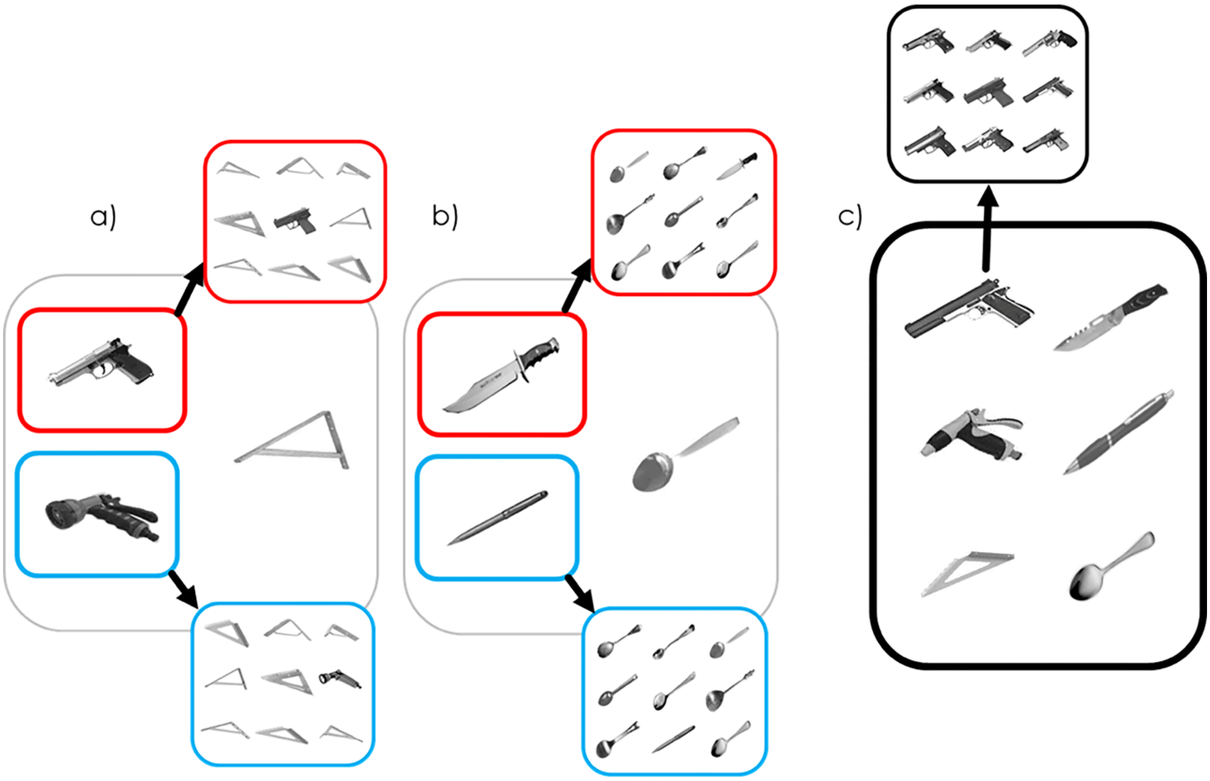

Figure 1.

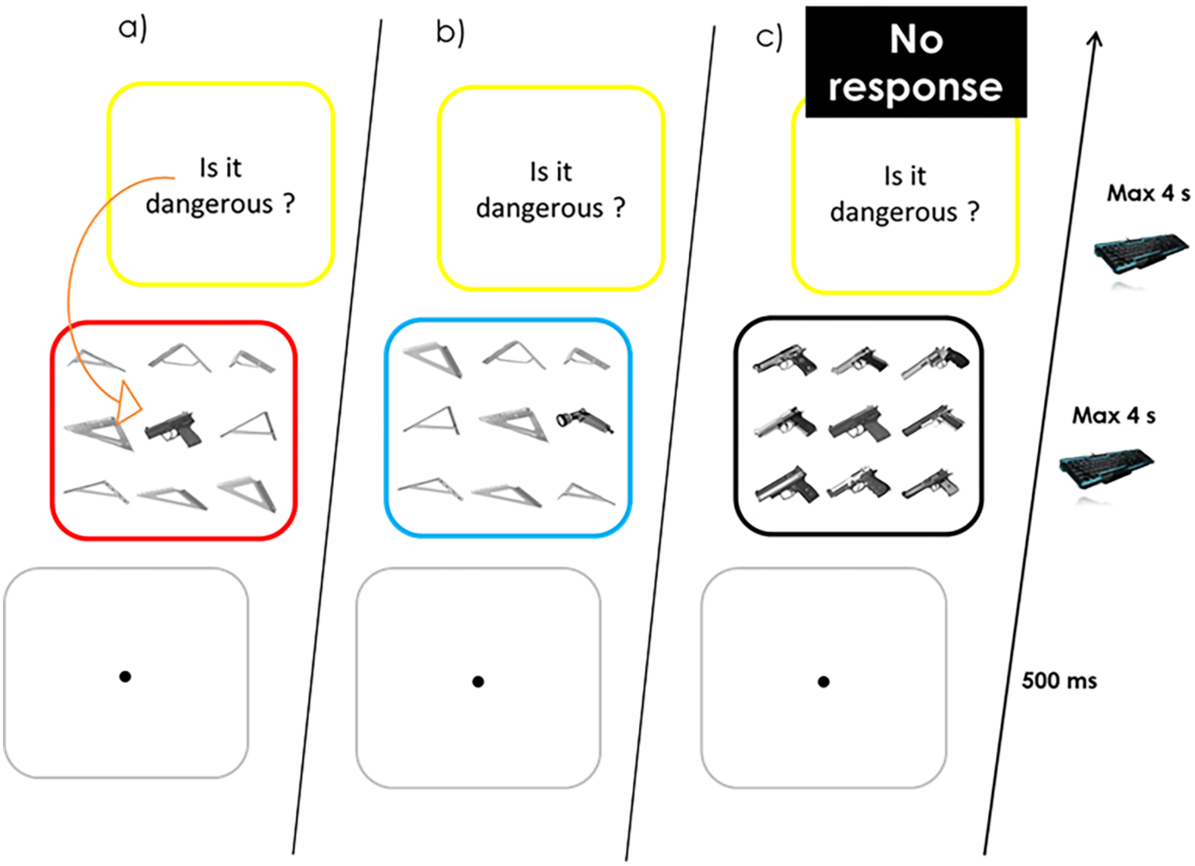
a)
b)
c)
No response
Is it dangerous ?
Is it dangerous ?
Is it dangerous ?
Max 4 s
Max 4 s
500 ms

Figure 2.

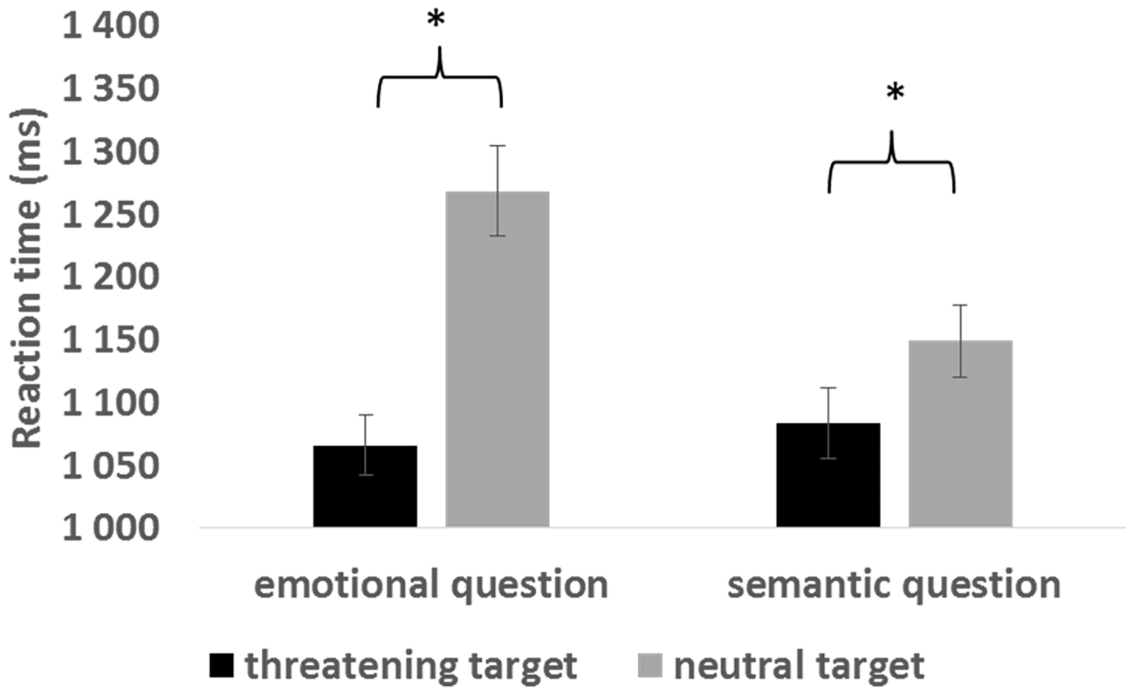
1 400
1 350
1 300
1 250
1 200
1 150
1 100
1 050
1 000
Reaction time (ms)
*
*
emotional question
semantic question
threatening target
neutral target

Figure 3.

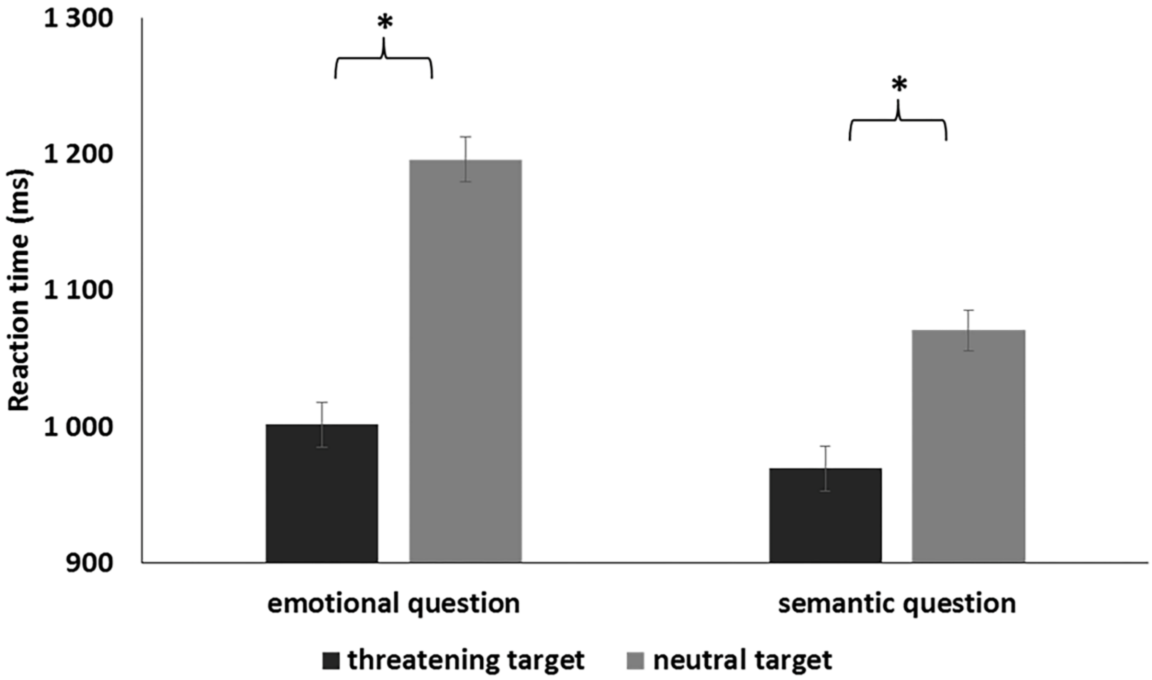
1 300
1 200
1 100
1 000
900
Reaction time (ms)
*
*
emotional question
semantic question
threatening target
neutral target

Figure 4.

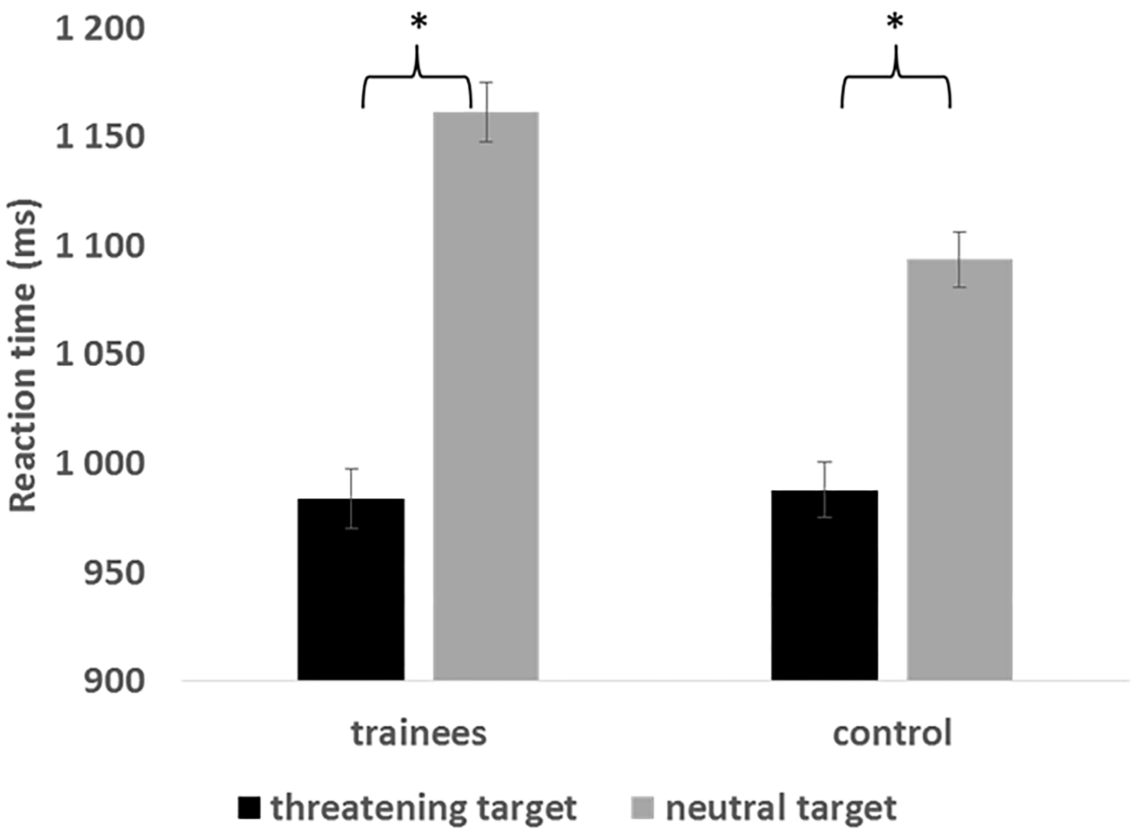
*
*
1 200
1 150
1 100
1 050
1 000
950
900
Reaction time (ms)
trainees
control
threatening target
neutral target

Figure 5.

Foot note

[1]Given that the Change in STAI-S deviated significantly from normality, Spearman rho correlations were also conducted, however these did not yield any statistically significant relationships for either processing strategy.