

A critical appraisal of processing visual threat

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ABSTRACT

The central issue in this thesis is how humans process visual threat. Rapid threat processing is proposed to be a valuable asset in terms of survival. Three main hypotheses were tested: (1) there is an association between the motor actions and threat processing, namely threat is responded to faster by avoiding it than approaching it. (2) Threat restricts the scope of attentional focus. (3) Threat is detected automatically and faster than non-threats. To control for possible confounding stimuli factors, photographic images of threatening cats, threatening dogs, non-threatening cats and non-threatening cats were used throughout three experimental chapters. To test whether threat processing is task-dependent, responses to threat were examined in three tasks: animal classification tasks (to judge whether the target images are cat images or dog images), threat classification tasks (to judge whether the target images are threatening or non-threatening) and speeded search tasks (to judge whether all the images are from the same category or there is one odd-ball image).

The consistent findings are: evidence from the animal classification tasks shows that responses to threatening stimuli were slower than those to non-threatening stimuli, however, this effect could be due to the familiarity of the animals (the non-threatening animals are more familiar to participants and easier to be classified) rather than stimuli valence. Evidence from the search tasks shows that threatening stimuli were detected faster than the non-threatening stimuli, however, by carefully controlling the stimuli factors, the magnitude of the threat detection advantage decreased. Overall, no robust evidence was uncovered that indicates a special sensitivity towards visual threat. The so-called threat effects may be in fact due to other factors, such as low level perceptual features of the stimuli and task requirements.

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DECLARATION

I declare that this thesis is original, unpublished, independent work by myself.

Yue Yue
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Chapter 1 Literature review

1. 1. Introduction

The topic of this thesis is how we respond to visual threat. Many studies have shown that attention is biased towards the detection of threat-relevance, such as fearful or angry faces (Bannerman, Milders, & Sahraie, 2010; Lipp, Price, & Tellegen, 2009; Mogg, Garner, & Bradley, 2007; Pinkham, Gribbin, Baron, Sasson, & Gur, 2010). It is claimed that this enhancement of attention occurs in the extremely early stages of visual processing (Phelps, Ling, & Carrasco, 2006) and does not require conscious awareness (Marcos & Redondo, 2005). Such biasing of attention towards threat is thought to promote evolutionarily adaptive behaviour that increases the likelihood of survival (LoBue, 2010).

In this thesis the relationship between visual threat and attention will be explored in mainly three ways. First of all, can threat processing influence our motor movements? From an evolutionary perspective visual threat (e.g., snakes, fearful or angry faces) has a particular value in promoting adaptive behaviours, such as avoiding potential dangers. Secondly, how does threat influence our spatial attention? If threat is presented in the focus of attention, do we ignore other information outside the focus and can we process threat when it is outside focus? Thirdly, can we detect threat fast and automatically? Overall, what are the mechanisms involved in threat processing?

The studies on how we respond to threat initially came from research on clinical populations, especially those with phobias or some other anxiety disorder. Later, non-clinical populations were included. Behavioural and neuroimaging experiments were carried out to explore how threat influences performance. A large array of stimuli were used in research studies, including emotional faces (e.g., Fox, Russo, & Dutton, 2002; Fox, Russo, & Georgiou, 2005; Palermo & Rhodes, 2007), emotional words (e.g., Kanske & Kotz, 2011), pictures of real life scenes (e.g., Yiend & Mathews, 2001) and movie clips (e.g., Straube et al., 2010).

The following review only focuses on non-clinical populations and does not provide an exhaustive revisit of the literature. Instead, it aims to provide an accurate reflection of the most relevant content from behavioural studies. Several

terms are referred to as visual threat, for instance, fear-related stimuli, threatening stimuli and negatively valenced stimuli. To maintain consistency ‘threatening stimuli’ is a generic phrase to cover visual threats.

1.2 Threatening stimuli and affective mapping effects

The first issue to be addressed relates to the so-called affective mapping effects. Some empirical evidence shows that better performance was found with positive–approach and negative–avoid assignments (congruent S-R pairing) than with negative–approach and positive–avoid pairings (incongruent S-R pairing). Such findings are collectively known as the affective-mapping effects (Eder & Rothermund, 2008). In the literature there are several different accounts of how to interpret the affective mapping effects and all of them rely on a rather limited body of studies. The specific-muscle-activation account claims that arm muscles are associated with responses to emotional stimuli (e.g., Chen & Bargh, 1999; Rotteveel & Phaf, 2004). However, there is a debate on the reliability of the associations between the motor movements and visual threat processing. Other accounts for affective mapping effects do not agree with the link between arm movements and the processing of emotional stimuli. For example, the distance-regulation account claims that the distance regulation (decreasing/ increasing the distance between the subjects and stimuli) is associated with responses to emotional stimuli (De Houwer, Crombez, Baeyens, & Hermans, 2001; Krieglmeier, Deutsch, De Houwer, & De Raedt, 2010; Lavender & Hommel, 2007). The reference matching account (van Dantzig, Zeelenberg, & Pecher, 2009; Zhang, Proctor, & Wegener, 2012) and the evaluative response coding account (Eder & Rothermund, 2008) pointed out that symbolic presentations of the stimuli/responses were essential for the affective mapping effects. The following sections will present a brief overview of these main accounts.

Specific-muscle-activation account

Pioneering theorists claimed that defensive and appetitive motivational circuits are activated by negative stimuli and positive stimuli, respectively. The activation of motivational states govern the automatic behavioural tendencies and humans spontaneously approach positive stimuli and avoid negative stimuli (e.g., Cacioppo, Larsen, Smith, & Berntson, 2004; Lang, Bradley, & Cuthbert, 1990). The

specific-muscle-activation account is based on the evidence that the affective mapping effects were found by manipulating arm movements (e.g., Cacioppo, Priester, & Berntson, 1993; Forster & Strack, 1996). It claimed that arm extension is associated with the processing of negative stimuli and arm flexion is associated with the processing of positive stimuli. The supportive evidence can be traced back to the studies by Solarz (1960). Negative and positive words were presented by a display box mounted on a response lever. When participants liked the objects corresponding to the stimulus word (positive words), they were faster to pull the lever towards them than to push it away. When participants disliked the words (negative words), they were faster to push the lever than to pull it.

The results from work of Solarz (1960) were replicated in the studies by Chen and Bargh (1999). In their Experiment 1 participants were required to judge the stimuli as 'good' or 'bad'. Half of the participants were instructed to push the response lever away from them if a positive word was presented and to pull the lever towards them if a negative word was presented. The opposite instructions were given to the other half of the participants. To test whether the affective mapping effects depend on conscious evaluation of the stimuli, the conscious evaluation task was removed in their Experiment 2. Participants simply reacted to the presence of stimuli (both positive and negative) by either pushing (in one block) or pulling (in the other block) the lever. The findings were that the responses to negative stimuli were faster when participants pushed the lever away than pulled it towards them and responses to positive stimuli were faster when participants pulled the lever than pushed it. Based on performance in conscious evaluation and non-evaluation tasks, Chen and Bargh (1999) claimed that the processing of emotional stimuli is the automatic consequence of arm flexion and extension. The arm extension (avoid) is associated with the processing of negative stimuli and the arm flexion (approach) is associated with the processing of positive stimuli, respectively. These effects were replicated by many other studies, such as using emotional pictures (Duckworth, Bargh, Garcia, & Chaiken, 2002; Rinck & Becker, 2007) and electric shock (Da Gloria, Pahlavan, Duda, & Bonnet, 1994).

However, evidence from some studies challenged the automaticity of the affective mapping effects, as well as whether arm movements were associated with these effects. Many studies found that arm flexion and extension were independent

of the affective-mapping effects (e.g., Bamford & Ward, 2008; De Houwer et al., 2001; van Dantzig, Pecher, & Zwaan, 2008). For example, in the study by Rotteveel and Phaf (2004) participants were required to respond to emotional faces by pressing a button rather than pushing/pulling a lever. Three buttons were positioned on a vertical stand. The home button was in the middle and there was one button at each end. In response to a stimulus, pushing the upper button required participants to flex their arms and pressing the lower button required participants to extend their arms. The affective mapping effects occurred in their Experiment 1, in which participants were required to judge the valence of facial expressions (happy, angry). Responses to angry faces were faster by pressing the lower button (extending the arm) and responses to happy faces were faster by pressing the upper button (flexing the arm). However, in their Experiment 2, in which participants need to judge the faces as 'female' or 'male', no affective mapping effects were observed. Rotteveel and Phaf (2004) interpreted these results as that the processing of emotional information was not automatically associated with the tendencies for arm flexion and extension.

In some studies contradictory evidence was found to question the influence of arm movements (e.g., Krieglmeier et al., 2010; Wentura, Rothermund, & Bak, 2000). For example, in the study by Lavender and Hommel (2007) emotional pictures (positive, negative) were rotated slightly either to the left or to the right in each display. Participants were asked to pull a lever away from or push it towards the computer screen as a response to the presence of emotional pictures. In the affective instruction participants were asked to judge the emotional valence of each picture. According to the specific-muscle-activation account arm flexion facilitate the responses to positive stimuli and arm extension facilitate the responses to negative stimuli. The results are opposite to what the specific-muscle account predicts. Negative stimuli were responded to faster by pulling the lever away from the screen (arm flexion) and positive stimuli were responded to faster by pushing the lever towards the screen (arm extension). In the spatial instruction participants were asked to judge the spatial orientation of each picture. No affective mapping effect occurred. These results supported the conclusion made by Rotteveel and Phaf (2004) that automatic affective visuo-motor links may not exist.

Distance regulation account

As introduced above, many studies disagree with the claims that arm extensions specially facilitate the processing of negative stimuli and that arm flexions specially facilitate the processing of positive stimuli. Furthermore, there is an argument as to whether the movement properties of an arm extension should be defined as ‘avoidance’ and whether motor patterns of an arm flexion should be defined as ‘approach’. These arguments inspired the development of the distance-regulation account. In the distance-regulation account approach and avoidance were interpreted in terms of the distance between the self and the object. ‘Approach’ was defined as decreasing the distance between oneself and the object and ‘avoidance’ was defined as increasing the distance (Strack & Deutsch, 2004). The results from the affective instruction condition in the studies by Lavender and Hommel (2007) can be interpreted in the distance-regulation account: positive stimuli were responded to faster by decreasing the distance (approach movements) and negative stimuli were responded to faster by increasing the distance (avoidance movements).

As ‘approach’ and ‘avoidance’ can be defined in terms of distance regulation rather than arm movements, an interesting question arises as to whether the arm movements are necessary for the occurrence of the affective mapping effects. Many studies showed that the answer is possibly ‘no’. For example, De Houwer, Crombez, Baeyens, and Hermans (2001) found affective mapping effects in tasks in which no arm movements were required. Participants were faster to press a button that moved a virtual manikin towards (decreasing the distance) a positive word than a button that moved the manikin away (increasing the distance) from the positive word; whereas responses to negative words showed the opposite pattern. This study supported the distance regulation account and also demonstrated that movement attributes of arm flexion and extension was not necessary.

Furthermore, De Houwer, et al. (2001) claimed that affective mapping effects depend on the activation of the highly abstract, symbolic representations of the self and the objects rather than the motor movements. This idea was tested and developed by other researchers. For instance, Markman and Brendl (2005) presented a corridor on a computer screen, where the participant's name (representing the self) was positioned in the middle of the corridor; and positive or negative words were

presented in front of or behind the name. The results showed that participants were faster to move a joystick that moved the positive words towards the name than away from it; and faster to move negative words away from the name than towards it. Markman and Brendl (2005) shed light on the cognitive mechanisms of affective mapping effects. As a result the reference matching account and evaluative response coding account were developed. These accounts do not focus on the relationship between the motor movements and the processing of emotional stimuli, but provide a new framework for thinking about affective mapping effects. These two accounts are introduced as follows.

Reference matching account

In recent years the reference matching account was developed by Van Dantzig, Zeelenberg and Pecher (2009), who interpreted the results from work by Markman and Brendl (2005) in a different way. The affective mapping effects depend on the match between the stimulus valence and the referent valence. When the valence matched, stimuli were responded to faster by moving towards the referent than moving away. When the valence has mismatched, stimuli were responded to faster by moving away from the referent than moving towards it. In the study by Markman and Brendl (2005) one's own name as a referent, is assumed to be a positive; positive stimuli matched the valence of the referent, therefore responses to the stimuli were faster by moving towards one's name than moving away. Negative stimuli mismatched the referent valence, therefore responses were faster by moving away than moving towards. To test the reference matching account, Van Dantzig, et al. (2009) used both a positive word (Love) and a negative word (Hate) as referent instead of the participant's name. Participants were asked to move a mouse (approximately 10 cm in a forwards or backwards direction) so as to move the stimuli towards or away from the referent. They found that the responses to positive stimuli were faster by moving towards the positive referent, however, the opposite pattern did not emerge when the referent was negative.

Zhang, Proctor and Wegener (2012) criticized the reason as to why Van Dantzig et al. (2009) did not find any effect in the negative referent cases was that the referent was too weak to have an influence on performance. To have a stronger impact, Zhang, et al. (2012) used pictures of Albert Einstein and Adolf Hitler as

referents. Participants were asked to move a joystick so as to move the word stimuli towards or away from the referent. The key findings were that when the referent was positive (Albert Einstein), responses to the positive stimuli were faster when moving them towards the referent; and responses to the negative stimuli were faster when moving them away from the referent. These were the affective mapping effects. When the referent was negative (Adolf Hitler), these relations reversed. Responses to negative words were faster when moving them towards the negative referent and responses to positive words were faster when moving away from the negative referent. Their results supported the reference matching account that the match between referent valence and stimuli valence facilitated the responses to stimuli and the mismatch between referent valence and stimuli valence interfered with the responses.

Evaluative response coding account

The reference matching account shed light on the relationship between the referent valence and stimuli valence; moreover, the evaluative response coding account noted that the responses could have an assumed valence as well and the response valence may influence the occurrence of affective mapping effects. The evaluative response coding account assumes that a behaviour labelled approach (e.g., “towards”) will be coded as positive, whereas behaviour labelled avoidance (e.g., “away”) will be coded as negative. When the stimuli valence is congruent with response valence, the stimuli can facilitate the response. Positive stimuli facilitate the “toward” response, and negative stimuli facilitate the “away” response. Supportive evidence came from the studies by Eder and Rothermund (2008). The affective-mapping effects were replicated when the standard response labels ‘towards’ and ‘away’ were used (in Experiment 1). However, the effects were reversed when identical lever movements were labelled ‘downwards’ and ‘upwards’ (In Experiments 2); and no such effects appeared when lever movements were labelled ‘right’ and ‘left’, which were unrelated to approach and avoidance (In Experiment 3). Affective-mapping effects depend upon the procedural characteristics of the task (i.e., action labels).

Although the evaluative response coding account sounds plausible, there is evidence against it. For example, Krieglmeyer, et al. (2010) were interested in

whether any responses been coded as positive and negative would be able to produce the affective mapping effects. They tested the findings from the study by Eder and Rothermund (2008) by using an adapted version of the manikin task designed by De Houwer et al. (2001). In this task, a positive or negative word was presented at the centre, whereas a manikin appeared in either the upper or lower half of the screen. Participants were required to press the up or down key on a keyboard to move the manikin towards or away from the stimulus. Participants were instructed to move the manikin “upwards” (positively labelled response) or “downwards” (negatively labelled response) without making a reference to the concept of approach-avoidance movements or the labels “towards” or “away”. Depending on the starting position of the manikin, upwards and downwards movements moved the manikin towards or away from the stimulus in the centre of the screen and therefore implied approach and avoidance movements, respectively. Results from their own studies showed that participants responded faster to the negative stimuli when the distance was increased than when it was decreased; and vice versa in responses to positive stimuli, regardless of the labelled actions. The results supported the distance regulation account but not the evaluative coding account.

Summary

To summarise, many experimental studies support the claim that approach and avoidance behaviours are automatically associated with the processing of emotional stimuli. The responses to the positive stimuli are faster when approaching them than avoiding them; and the responses to the negative stimuli are faster when avoiding them than approaching them; these are the affective mapping effects (Eder & Rothermund, 2008). Researchers defined the ‘avoidance’ and ‘approach’ in different ways and developed various accounts to understand the mechanisms of affective mapping effects. The specific-muscle-activation account claimed a link between the arm movements and the processing of emotional stimuli (e.g., Chen & Bargh, 1999). However, some evidence showed that affective mapping effects did not occur automatically (e.g., Rotteveel & Phaf, 2004), and there is a disagreement on whether arm extensions/flexions specially facilitated the responses to emotional stimuli (e.g., De Houwer et al, 2001). Apart from the specific-muscle-activation account, accounts for distance regulation, reference matching and response coding were also useful in explaining the affective mapping effects. Although there are a

variety of different interpretations, no specific account could explain all the empirical findings.

The main interest of this thesis is to explore the relationship between the motor responses and the visual threat. The avoidance and approach will be defined in terms of arm movements. As threat is one type of negative stimuli, responses to threat are predicted to be faster by avoiding threat than approaching it. This prediction will be tested in Chapter 2. Furthermore, in previous arm-movement studies the affective mapping effects were only found in the valence judgement task, but not in the non-valence judgement task (e.g., Lavender & Hommel, 2007). To explore whether task relevance is influential on affective mapping effects, both the valence and non-valence judgement tasks will be examined in Chapter 2. The mechanisms for affective mapping effects will be discussed based on current evidence in Chapter 2.

1.3. Threatening stimuli and spatial attention

Another approach to explore how we respond to visual threat is to examine how threat influences spatial attention. Two questions are relevant to this issue. One is that when threat is presented in the focus of our attention, how does it influence the processing of information outside the focus? The answer is mainly provided by the ‘attention narrowing’ account, which claims that threatening stimuli are found to narrow the scope of attention and impair the processing of stimuli outside the main focus of attention. The evidence supporting ‘threat narrows attentional scope’ was found by using flanker paradigms and will be introduced in more detail later. The other question is how do we process threatening stimuli when they are presented outside the main focus of attention? Are there any factors essential for the processing of parafoveal threat? The affective priming paradigm is one of the most useful paradigms to address this question and will be introduced in more detail after the flanker studies.

Threatening stimuli and the scope of spatial attention

The main question in this section is how typically stimuli influence the scope of spatial attention. The threatening stimuli have been tested with both neutral and positive stimuli in experiments. Researchers proposed that positive stimuli broaden

the scope of attention (e.g., Fredrickson & Branigan, 2005), and negative stimuli to narrow the scope of attention (e.g., Fenske & Eastwood, 2003).

The flanker paradigm (Eriksen & Eriksen, 1974) is a well established method for investigating the potential relevance of emotional stimuli for the scope of attention. In the standard version of the flanker task, participants are required to categorise a centrally presented target as quickly as possible, while ignoring any distraction presented as flankers on the left and right sides. The general finding of the flanker task is described as the flanker compatibility effect: Participants are faster to respond to the central target when the flankers are compatible as compared with incompatible. Normally, reaction times (RTs) to targets with compatible flankers are faster than RTs to targets with neutral flankers; and RTs to targets with neutral flankers are considerably faster than RTs to targets with incompatible flankers (e.g., Eriksen & Eriksen, 1974).

In the emotional version of the flanker task, one of the classic stimuli is the emotional schematic faces. The targets are centrally presented positive/negative faces, while the flankers are positive, negative and neutral faces presented on each side of the targets. The first emotional flanker task was conducted by Fenske and Eastwood (2003). In each display a target face was presented with two identical faces as flankers. The task was to identify the emotional valence of the central face (i.e., happy or sad), while ignoring the flanking faces. There were three flanker conditions: in the compatible flanker conditions, flankers and targets carried the same emotional valence; in the incompatible flanker conditions, flanker and targets carried opposite emotional valence; and in the neutral-incompatible flanker conditions, flankers had neutral valence. The most critical comparison was between the compatible and incompatible flanker conditions: When the central target was a positive face, the RTs for the incompatible flanker condition (with negative flankers) were significantly slower than the RTs for the compatible flanker condition. On the other hand, when the target was a negative face, the RTs for the two conditions were more or less the same. The explanation was that compared with positive faces and neutral faces, negative targets constricted the focus of attention, therefore impairing the influence of the flankers. In contrast, compared with neutral face trials, the positive targets broaden the scope of attention and increased attention can be shifted to process the flankers. As a result, flanker compatibility effects (RTs were slower in

the incompatible flankers conditions than those in the compatible flanker conditions) were found in the positive faces trials.

Following the studies by Fenske and Eastwood (2003), a debate was started about whether the flanker compatibility effects were due to the stimuli valence or the perceptual feature of stimuli. Many researchers claimed that the flanker compatibility effects can be caused by low-level perceptual features. For example, compared to positive faces, the interaction of face outline and mouth in the negative faces leads to curvature discontinuities and a concave edge (e.g., Humphreys & Muller, 2000; Stein & Sterzer, 2012). Watson, Blagrove, Evans and Moore (2012) examined performance when triangles, rather than faces, were used as the flankers. The triangles were downward pointing (potentially mimicking the components of a negative facial expression; Larson, Aronoff, & Stearns, 2007), upward pointing, or pointing outwards/inwards. When the triangle flankers were made more salient, downward pointing triangle flankers had the same effect on responses as negatively valenced faces.

Horstmann, Borgstedt, and Heumann (2006) replicated the flanker compatibility effects, but they pointed out that dissimilar responses to positive, neutral and negative facial stimuli may be due to differences in their perceptual attributes rather than the differences in their emotional valence. To demonstrate the perceptual account, Horstmann, et al. (2006) employed a number of different stimuli in four flanker experiments. In their most conclusive experiment (Experiment 4), using two completely non-emotional stimuli (a circle and a circle with a line intersecting its base), the similar asymmetric compatibility effects occurred as with schematic faces. This result indicates that flanker compatibility effects may be explained purely by perceptual factors.

Moreover, not only the perceptual cues of stimuli, but also the durations between the exposures of the targets and flankers could be the reason for the different magnitude of the flanker compatibility effects. For example, Schimdt and Schmidt (2013) employed the flanker paradigm, choosing the same sample size and number of trials as in Fenske and Eastwood's original study. In the new flanker paradigm, the temporal interval between presentation of the central target and flanker faces was varied. They found that the large compatibility effects were modulated by

temporal parameters, but not by emotional valence, therefore, they concluded that in their experiments the flanker compatibility effects were due to temporal parameters, but not emotional valence.

The studies introduced above all required participants to judge the stimulus valence as responses. The flanker experiments conducted by Zhou and Liu (2013) included non-valence judgement tasks. 6 female and 6 male faces generated in FaceGen Modeller 3.4, rather than schematic faces were selected as stimuli. Each face had a neutral, happy and a fearful expression. When participants were required to judge the emotional valence of the targets (positive, negative), results showed an emotion congruency flanker effect, participants responded faster to the targets with emotional congruent flankers than to those with emotional incongruent flankers. When participants were required to judge the gender of the targets (female, male), results showed a gender congruency flanker effects, participants responded faster to the targets with gender congruent flankers than to those with gender incongruent flankers; and the emotion congruency flanker effects diminished in the gender judgement task. Although these results did not directly relate to the 'threat narrows attention' account, it is important as Zhou and Liu (2013) pointed out that task relevance was one of the essential factors for the occurrence of the flanker compatibility effects. Emotion congruency flanker effects occurred when emotion was task relevant (e.g., in the valence judgement task).

Summary

The flanker studies reviewed above provide some useful points for consideration. The evidence for 'threat narrows attentional scope' was based on the flanker compatibility effects in the comparison between RTs from threatening target trials and those from non-threatening target trials. Therefore, in Chapter 3, the first important aim is to test the reliability of the flanker compatibility effects with new threatening and non-threatening stimuli. It was predicted that flanker compatibility effects occur in the non-threatening target trials; if threat narrows attention, such flanker compatibility effects do not appear in the threatening target trials. Furthermore, an important question to be addressed is whether the flanker compatibility effects are due to the stimuli valence or due to other factors, such as perceptual features of the stimuli and task requirements.

The processing of threatening stimuli outside the main focus of attention

Previously, the findings of flanker paradigms suggested that the central threat may narrow down the attentional scope and impair the processing of peripheral stimuli (Fenske & Eastwood, 2003). But how can the peripheral stimuli influence the processing of central threat? In this section the main question is does parafoveal threat influence performance? To address this issue, ‘spatial location’ is well described in terms of the visual field, which may be divided into the central, parafoveal area (2.5° away from a fixation point; Calvo & Lang, 2005) and the peripheral visual field (5.2° away from a central fixation point; Calvo, Nummenmaa & Hyona, 2007).

The affective priming paradigm has been one of the most useful tools, in which emotional scenes were widely used as stimuli (e.g., Hermans, De Houwer, & Eelen, 1994). In a single priming condition, a prime picture (positive, neutral, negative) was presented prior to the probe, to which participants needed to make responses; and in a dual priming condition, a pair of one emotional (positive, negative) and one neutral scene or a pair of two neutral scenes, were presented simultaneously prior to the probe. The recognition task and valence evaluation task are widely employed in the affective priming paradigm. In a recognition task, participants are required to judge whether a probe image was identical or related to previously presented prime images. In an evaluation task, participants are required to classify whether the probe is positive or negative. If the prime is assessed, shorter RTs to the probe will occur when it sharing congruent valence with the prime than when it does not. The general findings from the affective priming paradigms will be introduced as follows, starting with results from recognition tasks, followed by results from valence evaluation tasks.

In the recognition tasks, the recognition sensitivity was one of the measurements of how well participants respond to emotional stimuli. The probability of hits (i.e., correct “yes” responses to identical probes) and false alarms (i.e., incorrect “yes” responses to related probes) were converted to the A' index of recognition sensitivity (Snodgrass & Corwin, 1988). Calvo, Nummenmaa and Hyona (2007) found that in the single-prime condition, hit rate and recognition sensitivity were equivalent for emotional and neutral scenes. In the dual prime conditions,

greater recognition sensitivity and hit rate were found for emotional scenes (both negative and positive) than for neutral scenes. Moreover, there was impairment of sensitivity in the dual-prime condition for the neutral but not for the emotional scenes. Calvo, et al. (2007) concluded that the emotional stimuli captured more attention than neutral ones when they were presented in the para-foveal visual field.

Besides measuring recognition sensitivity and hit rate, more evidence for attentional bias towards emotional scenes was revealed by tracking eye movements. The general findings were that the first fixations were more likely to be preferentially directed towards emotional rather than neutral scenes, when pairs of one emotional and one neutral scene were presented simultaneously in peripheral vision (Calvo & Lang, 2004; Nummenmaa, Hyona, & Calvo, 2006). Moreover, Calvo, et al. (2007) found that saccade latencies towards emotional scenes was shorter than towards neutral scenes, even in the limited exposure time (300 ms, 450 ms), suggesting the orienting mechanism is triggered faster by emotional stimuli. In the study by Nummenmaa, Hyona, and Calvo (2006), when participants followed the instructions to look at the neutral picture, they were able to direct their gaze to the neutral stimuli after the first 650 to 700 ms until the display disappeared, which indicating the emotional content captured the attention automatically, and efforts were required to be counteracted voluntarily.

However, in some studies responses to emotional stimuli did not appear to be faster than neutral stimuli in the measurement of RTs (e.g., Calvo & Lang, 2005). Researchers identified several factors which may influence whether there is an advantage in processing of parafoveal emotional stimuli; for instance, foveal attention, task difficulty and exposure to emotional valence presented in the central visual field. These factors are introduced in more detail as follows.

In the studies by Calvo, Nummenmaa and Hyona (2008), the recognition advantage (sensitivity and hit rate) in the emotional over neutral scenes did not occur when the primes were presented for a short duration (e.g., 150 ms) and could not be fixated. In contrast, the recognition advantage occurred when there was enough time to foveally fixate a picture (450 ms). These results indicated that the recognition advantage was dependent on foveal attention. To find out whether foveal attention is required in processing the parafoveal emotional stimuli, many studies examined

performance when foveal attention is restricted. If foveal attention is necessary, the processing of parafoveal valence should be impaired without it.

One way to restrict the foveal attention was to manipulate the task difficulty. For example, in the study by Okon-Singer et al. (2007; Experiment 1), participants were presented with three rectangles on a computer screen. After a fixation cross in the middle rectangle, a brief flash in one of the peripheral rectangles was presented. A target letter was presented in one of the peripheral rectangles and a distracting picture was briefly presented in the other peripheral rectangle. Participants were asked to respond to the target letter and ignore the picture. They found that the peripheral emotional scenes did not impair the responses to letters. This suggests that difficult tasks interfered with the processing of the parafoveal information. Their studies showed that foveal attention is required in the processing of parafoveal valence (Calvo & Lang, 2005; Calvo & Nummenmaa, 2007; Erthal et al., 2005).

However, some studies found that the foveal attention was not necessary, but pre-exposure to the stimuli either in foveal, and/or parafoveal vision was crucial for processing parafoveal emotional stimuli (e.g., Calvo & Esteves, 2005). For example, to prevent foveal attention towards parafoveal stimuli, emotional stimuli outside the main focus were presented for a very short time (150 ms) in the study by Calvo and Castillo (2005). Participants were required to judge whether the centrally presented probe was a word or not. Results in the foveal priming condition and parafoveal priming condition both showed that participants responded to the probe threatening words faster after the presence of the threatening prime words, whereas this effect was not found in the neutral and positive word cases. Furthermore, in the study by Calvo and Nummenmaa (2007), the foveal attention was prevented by short presentation of a prime (150 ms), as well as by gaze-contingent foveal masking. Participants were required to judge the probe as 'pleasant' or 'unpleasant'. The finding was that the unattended prime (presented foveally or parafoveally) facilitated the affective evaluation of a centrally presented probe.

Moreover, Lichtenstein-Vidne, Henik and Safadi (2011), using flanker paradigms, found that the presence of emotional stimuli in the central visual field was necessary in the processing of peripherally emotional stimuli. In their study the targets were non-emotional pictures (Experiment 1) or emotional pictures (positive,

negative; Experiment 2) and appeared randomly above or below a central fixation cross. The flankers (positive, neutral or negative pictures) were always presented simultaneously in the peripheral columns, above, below, or at the level of fixation. In both of the experiments, participants were required to judge the up/down location of a central target. The negative flankers were found to slow down the responses to the central targets, but only when the targets were emotional pictures rather than non-emotional ones. They concluded that the processing of the parafoveal emotional information required exposure to emotional stimuli (positive or negative) in the central visual field.

Summary

To summarise, some evidence from affective priming paradigms showed that the emotional images in parafoveal vision can capture attention faster than non-emotional ones. There is an argument about whether the processing of parafoveally emotional stimuli required foveal attention. Evidence from experiments manipulating task difficulties suggested the foveal attention is necessary (e.g., Okon-Singer et al., 2007). However, there is evidence to suggest the opposite claim (e.g., Calvo & Castillo, 2005). No conclusive answers were provided for the argument.

In affective priming paradigms, some studies found that parafoveally negative primes can facilitate the responses to negative probes (e.g., Calvo & Castillo, 2005). In contrast, a finding from flanker paradigms (Lichtenstein-Vidne, et al., 2011) showed that when flankers and targets were presented simultaneously, the parafoveally threatening flankers interfered with responses to threatening targets. A question arises regarding flanker paradigms, if negative flankers are presented prior to the negative targets, what results can we find? The answer to this question was expected to be provided in Chapter 3.

Flanker paradigms were employed in Chapter 3. As the flankers can be presented before or at the same time as the presence of targets, the flanker paradigm has wider applicability than the affective priming paradigm. The evidence from current flanker experiments in Chapter 3 will be used to address how parafoveally threatening stimuli influence performance.

1.4. Rapid and automatic threat detection

Attention-capturing and attention disengagement

A variety of other methods were employed to explore how humans process visual threat (e.g., Yiend, Mathews, & Cowan, 2005). For example, a dot probe paradigm was employed, in which two cues (e.g., pictures) are simultaneously presented on a computer screen. A dot is presented after the cues and at the location of one of the cues. Participants are required to respond to the dot. RTs are faster when the dot is presented at the location of the threatening picture than when the dot is presented at the location of a neutral picture (e.g., Mogg & Bradley, 1999). This result can be explained as threatening cues captured attention and facilitated the responses to stimuli presented in the same location (valid) as threatening cues. Plenty of evidence has been found to support the claim that threatening stimuli grab attention (e.g., Larson, et al., 2007; Smith, Cacioppo, Larsen, & Chartrand, 2003; Vuilleumier, Armony, Driver, & Dolan, 2001). However, some evidence suggests that the reason for an attentional bias to threat is not ‘threatening stimuli capture attention faster than non-threatening stimuli’, but ‘threatening stimuli can hold attention longer than non-threatening ones’. The longer attention can be held, the slower it can be disengaged. The finding that shorter RTs were found when the dot was presented at the same location of the threatening cue can be explained by attention being difficult to be disengaged from threatening cues, therefore facilitating the responses to the valid dot.

The dot probe paradigm has difficulties in differentiating between attention-capturing and attention disengagement (e.g., Fox, Russo, Bowles, & Dutton, 2001) and an emotional modification of the exogenous cueing task (Posner, 1980) was used to solve this problem. In the modified version of the cueing task (Derryberry & Reed, 1994), only one stimulus was presented each time. If attention was allocated to the location of the threatening cue, this could have facilitated responding to targets presented at the same (valid) location of a cue, but no such effects have found when targets were presented at the opposite (invalid) location. If it was difficult to disengage attention from the threatening cue, then RTs should have been slower in responding to the target on the valid cue trials than on the invalid cue trials. Fox, Russo, Bowles, and Dutton (2001) used the cueing task and claimed that threat did

not capture attention, but modulated attentional holding. Their results have been replicated consistently in a variety of studies (e.g., Fox, Russo, & Dutton, 2002; Tipples & Sharma, 2000; Yiend & Mathews, 2001).

Some evidence suggests that task relevance influences threat processing (e.g., Huang & Yeh, 2011). For example, Barratt and Bundesen (2012) found threat captures attention only when it is task-relevant (e.g., in a valence judgement task). In their Experiment 1 participants needed to judge the valence of target faces with either compatible face flankers or incompatible face flankers; the results showed that negative faces were processed faster and attracted more processing resources. In their Experiment 2 participants needed to identify the target letters in three conditions: in the compatible letter conditions, compatible letters were presented as flankers. In the incompatible letter conditions, incompatible letters were presented as flankers. In the incompatible neutral conditions, schematic faces (either positive, negative or neutral) were presented as flankers. The results were that emotional faces (both negative and positive) did not affect performance. These findings suggested that attentional capture by emotional faces was task-dependent.

To address the issue of whether threat captures attention, threatening information is probably best investigated with a varying number of competing stimuli (Frischen, Eastwood, & Smilek, 2008). The visual search task is one of the most useful paradigms. The basic findings from visual search paradigms are that the threat can be detected automatically and rapidly (Öhman, Flykt, & Esteves, 2001); however, these results have been challenged by more recent evidence as outlined below.

The threat detection advantage and visual search tasks

In 1999, Öhman and his colleagues addressed the issue of how we respond to fear. They described a fear system which has evolved in survival within an environment; this system is sensitive to the detection of predators and “prompts physiological activation to support avoidance and escape” (p. 337). The fear system provides an early warning signal that primes the fight or flight response. Öhman, Flykt and Esteves (2001) developed the fear response hypothesis, the idea is that such a fear response is rapidly and automatically activated when threatening cues are present in the immediate environment. Visual search paradigm is the most useful

tool to test these hypotheses. In a standard visual search paradigm, participants were required to search for a target stimulus of a particular type in a search display that contains several stimuli. In the target-present condition, the target stimulus is presented among several distracters; participants have to press a key when they find the target. In the target-absent conditions, no target stimulus is presented; participants need to press a different key when they cannot find the target.

According to the fear response hypothesis, the detection of threatening target should be automatic and faster than to the detection of a non-threatening target; this has been known as the threat detection advantage. Supportive evidence was found in the studies by Öhman, et al. (2001); participants were required to search for a threatening target (spider or snake) among neutral distracters (flowers or mushrooms). In their Experiment 1 the display set size for searching the targets was fixed at nine items and in their Experiment 2 the display set size was either four or nine items. The most crucial evidence was that a flat search slope, a reaction time increase of less than 10 ms per additional distractor (Treisman & Gelade, 1980), was found, indicating that the threatening stimuli were detected automatically and more quickly than non-threatening stimuli.

Following Öhman's ground-breaking findings, many studies have used various versions of the speeded visual search task to examine the threat detection advantage. In a review by Quinlan (2013) 44 relevant experiments had been summarised. The so-called threat detection advantage was found to be confounded with methodological issues and stimuli factors. These confounds are introduced as follows.

One of the limits of Öhman's original study was that responses to targets were tested in displays comprising different sorts of non-targets. The so-called detection advantage could be due to coincident change in the distracter properties rather than the target valence (see Quinlan, 2013). Comparing the detection of a threatening target in a display which contains a target spider or snake and non-target images of mushrooms and flowers with the detection of a non-threatening target in a display which contains a target mushroom or flower and non-target images of spiders or snakes, it is difficult to know whether the threat detection advantage was the consequence of 'threatening target captured attention' or because it was easy to

search through the non-threatening non-targets. The slowed detection of a non-threatening target is possibly because attention is difficult to disengage from non-target threatening images (see Quinlan, 2013). Many studies without consistent distracter contexts have similar problems in interpreting their results (e.g., Blanchette, 2006; Fox, Griggs, & Mouchlianitis, 2007).

Another problem is that it remains unclear whether the threat advantage effects were due to threat or other stimuli factors (Cave & Batty, 2006). For example, Tipples, Young, Quinlan, Brooks and Ellis (2002) ran visual search tasks, using images of threatening/non-threatening animals and images of non-threatening plants. The finding was that not only the threatening animals, but also non-threatening animals were detected faster than the plants. Therefore, it seemed that the original claim of threat advantage may be actually due to better detection of animals than of plants. Quinlan (2013) pointed out that 11 cases which reported a threat advantage have the same categorical confound.

Moreover, Frischen et al. (2008) pointed out that in the visual search task, the difference in perceptual features (e.g., luminance and shape) between the threatening stimuli and neutral stimuli can encourage participants to use searching strategies in their search for the target. The perceptual feature of stimuli may be the reason for some reported threat detection advantage. For example, LoBue and DeLoache (2011) assessed performance in the cases where a coiled snake target was amongst images of other coiled objects and vice versa, no threat detection advantages were found. However, detection advantage was found in cases where the threat-irrelevant coiled objects were amongst images of flowers and in cases where coiled snakes targets were amongst images of flowers. LoBue and DeLoache (2011) therefore concluded that it was the snakelike, coiled shape, but not the threatening valence that caused such rapid detection.

As reviewed by Quinlan (2013) many visual search studies failed to find the threat detection advantage (e.g., Horstmann, Scharlau, & Ansorge, 2006; White, 1995). Surprisingly, Juth, Lundqvist, Karlsson, and Öhman (2005) found happy targets were detected more quickly and accurately than fearful targets in a crowd. Overall, the evidence for the threat detection advantage in visual search paradigms does not seem robust.

1.5. Overview of the following chapters

This brief review has shown three main hypotheses related to threat processing. The first one is the affective mapping effects, which claim that threat is responded to faster by avoiding it than by approaching it. Chapter 2 aims to test the affective mapping effects. The avoidance and approach behavioural tendencies are defined in terms of arm movement. The evidence from Chapter 2 can be used to address the issue of the relationship between the motor responses and threat processing.

Another hypothesis to be tested is the account of ‘threat narrows the scope of attention’. In Chapter 3 flanker paradigms are used to examine whether a centrally presented threat restricts attentional scope. The flanker compatibility effects are expected to occur in the non-threatening target cases, but such effects should disappear in the threatening target cases. Furthermore, the flanker experiments also explore how parafoveal threatening stimuli influence performance and if any conditions are required in the processing of parafoveal threat.

Finally, the threat detection advantage is tested in Chapter 4. Some evidence suggested that threat was detected rapidly and automatically. However, the reported threat detection advantage was found to have methodological confounds and stimuli confounds. Bearing in mind the confounds included in the review, selection of targets and non-targets and stimuli factors (i.e., colour, luminance) will be well controlled in the visual search tasks in Chapter 4.

On the basis of results from three experimental chapters, a general discussion will be addressed in Chapter 5. The main aim is to contribute to the understanding of how we respond to threat.

Chapter 2 Threat processing and motor movements

2.1. Introduction

To survive in environment, humans need to rapidly process emotional and, in particular, threatening stimuli. Evidence from a large number of studies has shown that attentional resources are biased towards emotional stimuli, particularly fearful and threatening ones (for a review, see Vuilleumier, 2005). Reactions to emotional stimuli, however, consist of a much more complex pattern of responses, involving behavioural, physiological and cognitive ones (e.g., Lang, 1994). This chapter aims to explore the relationship between threat processing and motor actions, based on research of the *affective-mapping effect* (Eder & Rothermund, 2008). As a general role, it has been found that better performance has been found with positive–approach and negative–avoid assignments (congruent S-R pairing) than with negative–approach and positive–avoid pairings (incongruent S-R pairing). Such findings have been interpreted as the support for the link between stimuli evaluation and motor responses (e.g., Cacioppo et al., 1993; Forster & Strack, 1996). This has been developed in various accounts. The review below focuses on the specific-muscle-activation account, and extends details of the important experiments, which have been introduced in Chapter 1. Other accounts for the *affective mapping effect* are outside the scope of this chapter.

In the specific-muscle-activation account, arm extension is defined as the avoid tendency, and arm flexion is defined as the approach tendency (e.g., Chen & Bargh, 1999). In the pioneering study by Solarz (1960), half of the participants in the study were instructed to pull a lever towards them if a positive word was presented and to push the lever away from them if a negative word was presented; the remaining participants were given the opposite instructions. The results were that responding to positive words was faster by pulling the lever than pushing it and responding to negative words was faster by pushing the lever than pulling it. These results were replicated by Chen and Bargh (1999) in their two experiments. In their Experiment 1, participants were required to judge whether the stimuli were ‘good’ or ‘bad’. The task instructions were the same as given by Solarz (1960). In their Experiment 2 participants did not consciously judge the emotional words, but simply reacted to the presence of each positive or negative stimulus as quickly as they could by either pushing (in one block) or pulling (in the other block) the lever.

Chen and Bargh (1999) concluded that arm extension (avoid) is linked with the processing of negative stimuli and arm flexion (approach) is associated with the processing of positive stimuli, respectively. The affective-mapping effects automatically associated with arm movements (flexion and extension), regardless of the conscious evaluation of the stimuli. Many studies supported the link between the affective mapping effects and arm extension and flexion (e.g., Da Gloria, Pahlavan, Duda, & Bonnet, 1994; Rinck & Becker, 2007). For example, Duckworth, et al. (2002) found the affective-mapping effects, when participants were required to push (in the avoidance condition) or pull (in the approach condition) a lever to respond to the presence of emotional images.

However, some studies found arm movements (flexion and extension) dissociated from the affective-mapping effects (e.g., Bamford & Ward, 2008; De Houwer et al., 2001; van Dantzig, et al., 2008). For example, in studies by Rotteveel and Phaf (2004), emotional faces were selected as stimuli. Participants were required to make responses by pressing buttons instead of moving a lever. The response buttons were positioned perpendicularly above and below a home button on a vertical stand; and the participants were to push the lower (arm extension) or upper (arm flexion) button in response to the stimuli. In their Experiment 1, participants were asked to classify facial expressions (happy faces, angry faces). In their Experiment 2, participants were asked to classify the same stimuli as in Experiment 1, but now the gender (female, male). The results showed that the affective mapping effects occurred in the facial expression judgement task. Participants classified angry faces better by pressing the lower button and they classified happy faces better by pressing the higher button. However, no affective mapping effects occurred in the gender judgement task (when no conscious evaluation was required). Therefore, Rotteveel and Phaf (2004) conclude that the processing of emotional information was not automatically associated with arm movements.

Evidence from some studies was opposite to the findings from Chen and Bargh (1999; e.g., Krieglmeier et al., 2010; Wentura, et al., 2000). For example, Lavender and Hommel (2007) used emotional pictures (positive, negative), which were rotated either slightly to the left or to the right in each display. In the emotional valence judgement task, participants were required to judge each picture as 'pleasant' or 'unpleasant'. Positive stimuli were responded to faster by pushing the lever towards the screen (arm extension) and negative stimuli were responded to

faster by pulling the lever away from the screen (arm flexion). According to the specific-muscle-activation account, arm extension is associated with the responses to negative stimuli and arm flexion is associated with the responses to positive stimuli, but Lavender and Hommel (2007) found the opposite to these predictions.

Furthermore, in spatial orientation judgement tasks, when participants were required to judge the orientation of each picture (left, right), no affective mapping effects were found. Based on the evidence from these two experiments, Lavender and Hommel (2007) supported the conclusion made by Rotteveel and Phaf (2004) that the association between processing emotional stimuli and arm muscles may not exist.

In brief, evidence from studies on how motor actions influence the processing of emotional stimuli was controversial. Many studies found the affective mapping effects and have supported the claim that there is an automatic association between motion actions on the processing of emotional stimuli. However, some evidence showed that the affective mapping effects occurred in valence evaluation tasks, but they were not always found in the non-valence judgement tasks. In the current experiments the occurrence of affective mapping effects were examined in different task requirements, and both valence and non-valence tasks were included. In the specific-muscle-activation account the approach and avoidance behaviours were conceptualized as arm flexion and extension, respectively. However, some evidence showed the definition of ‘approach’ and ‘avoidance’ may be problematic. In the current experiments, the avoidance behaviour tendency is defined as avoiding from the stimuli, which required arm flexion and the approach behaviour tendency is defined as approaching to the stimuli, which required arm extension. The aim of this chapter is to examine the association between the avoidance behaviours and the processing of threatening stimuli. High ecological stimuli – pictures of threatening and non-threatening animals were used. In previous studies, non-threatening stimuli were often selected from a different category to threatening ones. To control the category confound, both threatening and non-threatening pictures were selected from the same animal categories. According to the affective mapping effects, threat is predicted to be responded to faster by avoiding it than approaching it.

2.2. Experiment 1

In order to collect indicators of general performance two different classification tasks were used in Experiment 1. The *animal classification task* is a non-valence judgement, in which participants were instructed to judge whether the picture depicted a cat or a dog and to respond accordingly. The *threat classification task* is a valence judgement task, in which participants were instructed to judge whether the picture depicted a threatening or a non-threatening animal and to respond accordingly. Four sets of stimuli were chosen, images of threatening cats (including tigers, lions, panthers), images of non-threatening cats, images of threatening dogs (including fighting dogs, wolves), and images of non-threatening dogs. Each coloured image depicted only one animal, facing front in a natural background (Figure 2.1.).



Figure 2.1. Examples of (a) image of a threatening cat, (b) image of a non-threatening cat, (c) image of a threatening dog, (d) image of a non-threatening dog.

Many studies have indicated that threat facilitated task performance. Threatening stimuli are responded to more rapidly than neutral and positive stimuli (e.g., Smith, Cacioppo, Larsen, & Chartrand, 2003). For example, attention is rapidly oriented towards faces displaying fear or anger (Eastwood, Smilek, & Merikle, 2003; Fenske & Eastwood, 2003; Fox & Damjanovic, 2006), threatening words and scenes (Fox et al., 2001; Yiend & Mathews, 2001; Koster et al., 2004). This attentional bias towards threat was explained from an evolutionary point of view. It is believed that

attentional bias to threat facilitates locating and processing danger, immediate responses to threat can prevent loss of life and enhance the chance of survival in environment (e.g., Pratto & John, 1991).

In contrast, some evidence suggests that the presence of threat can impair performance. People find it difficult to disengage attention from the threat item (Fox et al., 2001, 2002; Yiend & Mathews, 2001). As a result, this delayed disengagement from negative stimuli elicits relatively slow responses to ongoing cognitive tasks, such as word naming (e.g., Algom, Chajut, & Lev, 2004; Estes & Adelman, 2008), lexical decisions (Estes & Adelman, 2008; Wentura, et al., 2000).

So there is evidence that negative stimuli can facilitate as well as impair performance, depending on the task requirements. Estes and Verges (2008) set out a response-relevance hypothesis: responding to threat is task-dependant. Possibly, negative stimuli only elicit slow responding in tasks, when stimulus valence is irrelevant to responses (i.e. in a non-valence judgement). In tasks, where stimulus valence is response-relevant (i.e. in a valence judgement), negative valence should elicit relatively fast responses. The response-relevance hypothesis was supported by the studies of Estes and Verges (2008). Participants in different conditions were required to make lexical decisions (to judge whether each letter string was a word or a non-word in Experiment 1) and valence judgements (to judge whether each word was positive or negative in Experiment 2) of negative and positive words. Participants responded to the negative words (e.g., spider) more slowly than the positive words (e.g., kitten) in the lexical task, but faster in the valence judgement task. Joining up with the response-relevance hypothesis, in the current experiments, the threats were predicted to be responded to more slowly than the non-threats in the animal classification task and faster than the non-threats in the threat classification task.

Studies have found that interference with task performance could be due to the arousal rather than valence of the threats (Verbruggen & De Houwer, 2007; De Houwer & Tibboel, 2010). Arousal could be an important factor in threat processing. Therefore, following completion of the two classification tasks, participants were required to rate the scores for stimuli sets on valence and arousal. The threatening stimuli were presumed to have higher scores than the non-threatening stimuli in both rating tasks.

2.2.1. Method

Apparatus and Stimuli

E-prime (Schneider, Eschman, & Zuccolotto, 2002) running on a Windows 2000 PC, was used for controlling the experiment. Two independent response buttons were connected to the E-prime button box. The individual pictures were sourced from various Internet searches and some items were taken from the IAPS (see Lang, Bradley & Cuthbert, 1998). Four types of stimuli were selected: threatening cats, threatening dogs, non-threatening cats and non-threatening dogs. Each type of animal set comprised 48 photographs for the test trials, and another three images for the practice trials. Each coloured image was 4.1° (wide) x 3.2° (high) visual angle.

Design and Procedure

Participants were tested in a quiet, windowless cubicle and sat at a table in front of a chin rest situated 57 cm from a computer screen which was located on a raised plinth. The centre of the screen was at eye-level. The screen and buttons were linked to another computer situated outside the cubicle. Written instructions were presented first to explain the tasks and the stimuli. All participants were required to complete two tasks: the animal classification task and the threat classification task. In the animal classification task, participants need to press the 'left' button to respond to the images of cats, and to press the 'right' button to respond to the images of dogs. In the threat classification task, the 'left' button was pressed when participants responded to the threatening images, and the 'right' button was pressed when participants responded to the non-threatening images. Half of the participants did the animal classification task first, followed by the threat classification task; the other half of the participants did the tasks in reverse order.

Each task was tested in 2 blocks of 96 trials. The order of presentation of the 192 images was randomised and divided into the two blocks such that no image within one task was presented more than once. Prior to the blocks of experimental trials, 12 practice trials were administered. The images in the practice trials were different from those on the experimental trials. Each participant received a different random order of the images. A single stimulus was displayed at the centre of the screen after the presentation of a central fixation point lasting 600 ms. Participants were instructed to respond to the stimuli as quickly and as accurately as possible on

each trial. Both tasks were completed in a single testing session lasting approximately 35mins.

After finishing the two tasks, the four sets of pictures (threatening cats, threatening dogs, non-threatening cats and non-threatening dogs) were rated on 7-point scale for valence, and arousal. Each trial started with the presentation of one image of a cat or dog for 500 ms in the centre of the screen. A scale ranging from 1 (minimum) to 7 (maximum) was presented underneath. The same image was presented twice in a trial, one was for the rating of valence, and the other was for the rating of arousal. Participants were instructed to judge their immediate feelings and not to think in detail about the picture or its contents in terms of particular properties, that is particular feelings or thoughts it might invoke (e.g., fear, anger, joy, etc.). The stimuli were presented in random order.

Participants

Twenty-four naive participants (mean age = 20, 22 female) were recruited from students at York University. There were three left-handed individuals. They received either course credit or £5. All of the participants reported normal or corrected-to-normal vision.

2.2.2. Results

The main interest of the analysis was with correct RTs and percentage error rates, which were first converted into proportions and then arcsin transformed following the advice of Keppel and Wickens (2004).

Lofuts and Masson (1994) addressed the issue of which type of error bars should be reported in using repeated measure designs. They have recommended using a pooled measure, in which estimates of variability derive directly from the mean squares of ANOVA. However, Bakeman and McArthur (1996) argued that error bars serve for describing a pattern of population parameters, it makes more sense to estimate variability for scores from each condition separately. The within-participant error bars presented in graphs throughout the thesis reflect the variations across different trial conditions, and were calculated using the adjusted scores recommended by Bakeman and McArthur (1996): $W_{ij} = Y_{ij} - (Y_i - Y_{..})$, i index subject and j index repeated measure; W_{ij} and Y_{ij} represent adjusted and raw scores,

respectively; Y_i is the mean score for each subject across repeated measures and $Y...$ is the grand mean for all scores.

2.2.2.1. Animal classification task

The mean correct RTs were analysed with a 2 (valence: threatening vs. non-threatening) x 2 (animal category: cat vs. dog) repeated measures ANOVA. The analysis revealed a statistically significant main effect of valence, $F(1, 23) = 68.9$, $MSE = 2285.6$, $p < .001$. Participants responded to the threatening images more slowly than the non-threatening images (mean RTs were 767 ms and 676 ms for threatening target images, and non-threatening target images, respectively; see Figure 2.2.). No other effects were found to be statistically significant.

The analysis of the error rates revealed a statistically significant main effect of valence, $F(1, 23) = 9.3$, $MSE = .0126$, $p < .05$ (the error rates were 4.3%, and 2.1% for the threatening images and non-threatening images, respectively). The main effect of the animal category was also found to be statistically significant, $F(1, 23) = 6.7$, $MSE = .0086$, $p < .05$ (the error rates were 4.5% and 2.3% for the cat images and dog images, respectively).

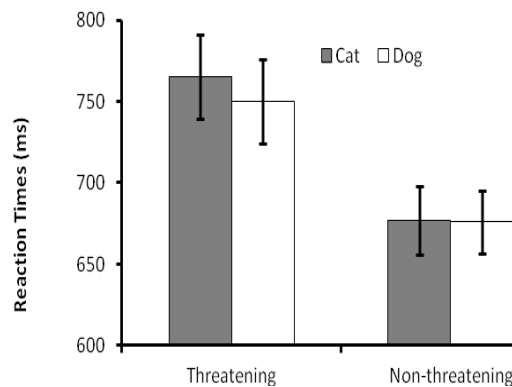


Figure 2.2. Mean reaction times for threatening cats, threatening dogs, non-threatening cats and non-threatening dogs in the animal classification task of Experiment 1. Error bars reflect within-participants standard errors.

Summary

Participants responded to the threatening images more slowly and less accurately than to the non-threatening images. The dog images were classified more accurately than the cat images. There was no evidence for any systematic speed-accuracy trade offs in the data.

2.2.2.2. Threat classification task

The mean correct RTs were analysed with a 2 (valence: threatening vs. non-threatening) x 2 (animal category: cat vs. dog) repeated measures ANOVA. The analysis revealed a statistically significant main effect of animal category, $F(1, 23) = 13.9$, $MSE = 1603.1$, $p = .001$ (mean RTs were 643 ms and 674 ms for cat images, and dog images, respectively; see Figure 2.3.). The valence x animal category interaction was also found to be statistically reliable, $F(1, 23) = 8.1$, $MSE = 1311.1$, $p < .05$ (the mean RTs were 628 ms, 679 ms, 659 ms, and 668 ms for the threatening cat images, threatening dog images, non-threatening cat images, and non-threatening dog images, respectively). An HSD test ($\alpha = .05$) revealed that the only statistically reliable difference arose for the threatening cat images. Participants responded to the threatening cat images faster than the other three types of images ($p < .05$), and no significant difference of responses was revealed in the cases of non-threatening cats, threatening dogs and non-threatening dogs ($ps > .05$).

The analysis of the transformed error rates revealed a statistically significant valence x animal category interaction, $F(1, 23) = 5.5$, $MSE = .006$, $p < .05$ (the error rates were 1.7%, 4.5%, 2.4% and 2.3% for the threatening cat images, threatening dog images, non-threatening cat images, and non-threatening dog images, respectively). An HSD test revealed that the threatening dog images were classified less accurately than the other three types of images ($p < .05$), and there were no further statistically significant differences (all $ps > .05$).

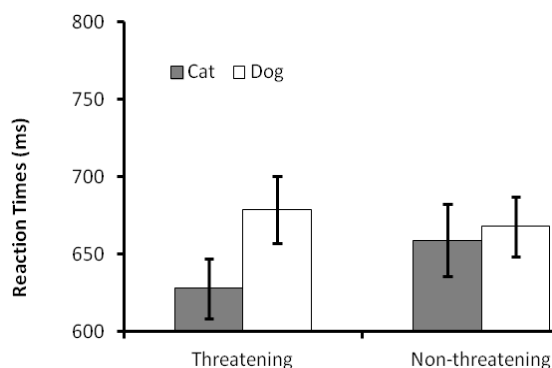


Figure 2.3. Mean reaction times for times for threatening cats, threatening dogs, non-threatening cats and non-threatening dogs in the threat classification task of Experiment 1. Error bars reflect within-participants standard errors.

Summary

The cat images were classified faster than the dog images. Particularly, participants responded to the threatening cat images faster than the other three types of stimuli. In addition, the threatening dog images were found to be responded to less accurately than other types of stimuli. There were no apparent reasons for this effect in the current data for the threatening dog trials. Also, there was no evidence for any systematic trade-offs in the data.

2.2.3. Ratings

The mean rating scores of valence and arousal were analysed separately using the same kind of ANOVA, namely a 2 (valence: threatening vs. non-threatening) x 2 (animal category: cat vs. dog) repeated measures ANOVA. The analysis of the valence rating scores revealed a statistically significant main effect of stimuli valence, $F(1, 47) = 2939.5$, $MSE = .203$, $p < .001$ (the mean scores were 5.2 and 2 for threatening images and non-threatening images, respectively). The analysis of the arousal rating scores revealed a statistically significant main effect of stimuli valence as well, $F(1, 47) = 2641.9$, $MSE = .012$, $p < .001$ (the mean scores were 5.3 and 2.7 for the threatening and non-threatening images, respectively; see Figure 2.4.). The threatening stimuli were well selected in terms of valence; indeed they are more threatening than the non-threatening stimuli.

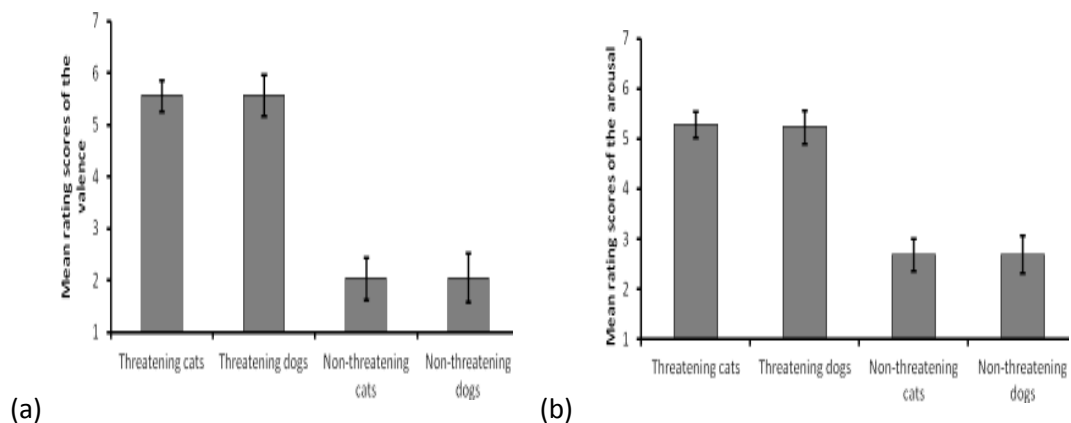


Figure 2.4. Means and standard deviations of rating scores for the stimuli set.

2.2.4. Discussion

Stimulus valence was found to influence performance differently across the non-valence and valence judgement tasks. There was evidence that the threat images slowed down responses in the animal classification task. In contrast, threat operated differently in the threat classification task. There was evidence to suggest that threatening images were responded to faster than non-threatening images. This effect was only obtained for the cat images.

The findings of the present experiment, therefore, fit reasonably comfortably with the predictions of the response-relevance account (Estes & Verges, 2008), which is based on the delayed disengagement mechanism (Fox et al., 2001; Yiend & Mathews, 2001). Attention is disengaged more slowly from negative stimuli than from other stimuli. In the non-valence judgement task (animal classification task), attention must be disengaged from the valence of the stimulus. The slower disengagement evoked slower responding to the task. Therefore, the threats were generally responded to more slowly than the non-threats (Algom, et al., 2004; McKenna & Sharma, 1995; Pratto & John, 1991; Wentura et al., 2000). In the valence judgement task, that is the threat classification task, no attentional disengagement was required from the valence of the stimulus. The threat can hold attention longer, and be responded to, relatively faster than the non-threats.

The results suggest that the influence of threat on performance was task-dependant. Apart from the response-relevance hypothesis, alternative explanations also remain viable. The threats might be easy to be classified by the valence rather than by the animal category. The slower responses to the threats might occur in any relatively difficult task, not just for non-valence judgement tasks. Although the present results could be explained by the response-relevance account, the other alternative explanations could not be ruled out completely.

2.3. Experiment 2

The set up in Experiment 1 was a very simple paradigm to test how threat was responded to in two different tasks (a non-valence and a valence judgement task, respectively). In Experiment 2 the responses to threat in these two tasks were tested in a different way. Now participants were required to make different motor actions (i.e., approach triggered by arm extension, and avoidance triggered by arm flexion)

to the stimuli under different instructions. The same classification tasks as in Experiment 1 were used.

In the studies of Rotteveel and Phaf (2007), negative and positive faces (male, female) were presented as stimuli. Participants were required to judge the gender of the target stimuli in the non- valence judgement task, and to judge the target stimuli as ‘positive’ or ‘negative’ in the valence judgement task. The affective mapping effects, the negative stimuli were to be responded to faster by avoiding from it than approaching to it, the positive stimuli were responded to faster by approaching to it than by avoiding from it, occurred only in the valence judgement task. The current experiments aimed to test the advantage association between threat processing and avoidance behaviour tendencies in different conditions of task instructions. The threatening images were predicted to be responded to faster by avoiding them than approaching them in the threat classification task, but not in the animal classification task.

2.3.1. Method

Apparatus and Stimuli

In order to measure approach and avoidance responses, a spar with response keys was used. Three response keys were fixed on the wooden spar, positioned on each end and the middle (Figure 2.5.). The spar was placed on the testing table, between the seat and the screen of a 15" SONY monitor (model CPD-100ES). The spar was angled towards the screen such that the end closest to the participants was at the level of the table top whereas the end farthest from the participants was raised to the bottom of the screen. The participants were supposed to approach the stimuli on the screen by moving the arm from the middle button to press the forward-button; and to avoid the stimuli on the screen by moving the arm from the middle button to press the backward-button. The stimuli used in Experiment 1 were used in the Experiment 2.

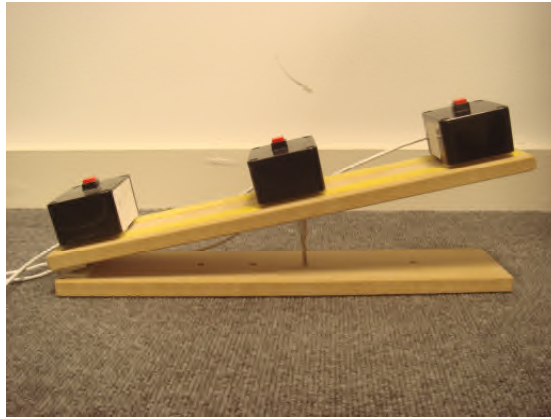


Figure 2.5. Illustration of the response device used in Experiment 2.

Design and Procedure

Firstly, written instructions were presented to explain the tasks and the stimuli. Each participant was required to complete two tasks: the animal classification task and the threat classification task. In the animal classification task, half of the participants needed to move their arms forwards to respond to the cat images, and move their arms backwards to respond to the dog images. The other half of the participants was required to give the opposite responses. In the threat classification task, half of the participants needed to move their arms forwards to respond to the threatening images, and move their arms backwards to respond to non-threatening images. The other half of the participants was required to give the opposite responses.

Each task was completed in a single testing session lasting approximately 15 mins. The sequence of the tasks was balanced across participants. In each task a 12 trial practice block preceded four testing blocks. The practice block comprised 3 images of threatening cats, 3 images of non-threatening cats, 3 images of threatening dogs and 3 images of non-threatening dogs. Each testing block comprised 12 images of threatening cats, 12 images of non-threatening cats, 12 images of threatening dogs and 12 images of non-threatening dogs. Each image was only presented once.

Participants were required to press the middle button on the response bar to start the experiment. Each trial began with a 1,000 ms presentation of a centrally-positioned fixation cross, which was immediately followed by one image presented at the centre of the screen on a white background. The stimulus remained on the screen until a response had been made by either pressing the forward-button or

backwards-button. RTs were measured from the onset of the stimulus display. Between the blocks participants were allowed to rest.

Participants

Sixteen naive participants (mean age = 21, 14 female) were recruited from students at York University. There were three left-handed individuals. They received either course credit or £4. All of the participants reported normal or corrected-to-normal vision.

2.3.2. Results

2.3.2.1. Animal classification task

The mean correct RTs (Figure 2.6.) were analysed with a 2 (valence: threatening vs. non-threatening) x 2 (animal category: cat vs. dog) x 2 (movement: arm extension vs. arm flexion) repeated measures ANOVA. The analysis revealed only a statistically significant main effect of valence, $F(1, 15) = 28.5$, $MSE = 2639$, $p < .001$; participants responded to the threatening images more slowly than to the non-threatening images (mean RTs were 1016 ms and 967 ms for threatening images and non-threatening images). No other effects were found to be statistically significant.

The same sort of analysis was carried out on the transformed error rates. The only statistically significant test was the main effect of valence, $F(1, 15) = 4.8$, $MSE = .002$, $p < .05$. Participants were less accurate with threatening images than non-threatening images (the error rates were 2.6% and 1.3% for threatening images and non-threatening images, respectively).

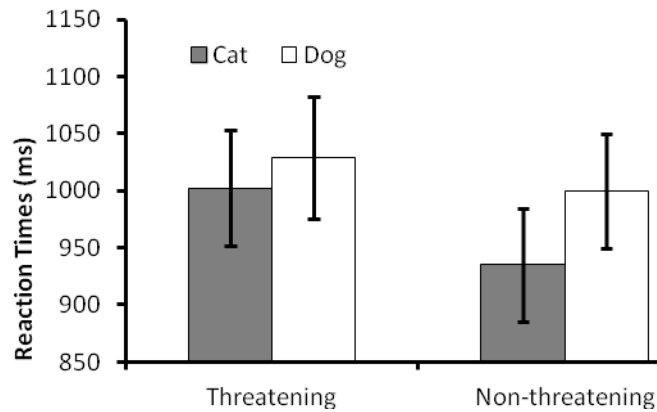


Figure 2.6. Mean reaction times for threatening cats, threatening dogs, non-threatening cats and non-threatening dogs in the animal classification task of Experiment 2. Error bars reflect within-participants standard errors.

Summary

The results showed that threatening images were responded to more slowly and less accurately than non-threatening images. Moreover, there was no evidence for any difference in response speed to threats regardless of whether an approach or an avoidance response was required. There was no evidence of any systematic speed-accuracy trade offs in the data.

2.3.2.2. Threat classification task

The same method of RTs analysis used in the animal classification task was used in the RTs of the threat classification task (Figure 2.7.). The analysis revealed a statistically significant valence effect, $F(1, 15) = 8.6$, $MSE = 5590.4$, $p < .05$; participants responded to the threatening images faster than the non-threatening images (mean RTs were 1030 ms and 1069 ms for threatening images and non-threatening images, respectively). The main effect of the animal category was also found to be statistically significant, $F(1, 15) = 6.8$, $MSE = 4225.4$, $p < .05$; cat images were responded to faster than the dog images (mean RTs were 1034 ms and 1064 ms for cat images and dog images, respectively).

Error analysis revealed a statistically significant main effect of the animal category, $F(1, 15) = 24.6$, $MSE = .004$, $p < .001$; the cat images were responded to more accurately than the dog images (the error rates were 0.9% and 2.1% for cat images and dog images, respectively).

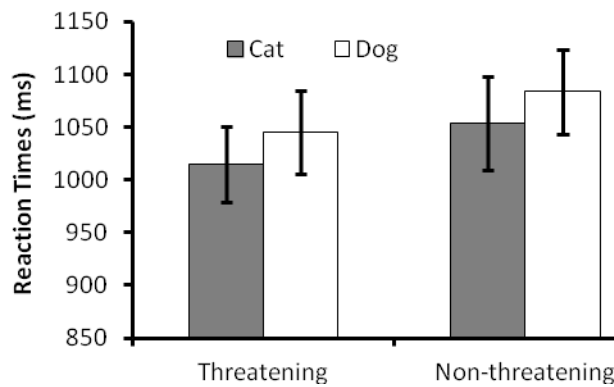


Figure 2.7. Mean reaction times for threatening cats, threatening dogs, non-threatening cats and non-threatening dogs in the threat classification task of Experiment 2. Error bars reflect within-participants standard errors.

Summary

The results showed participants responded to the threatening images faster than the non-threatening images, and responded to the cat images faster and more accurately than the dog images. There was no evidence for an association between the avoidance and the threat processing.

2.3.3. Discussion

The affective mapping effect was predicted to occur in the valence judgement task (the threat classification task), but not in the non-valence judgement task (the animal classification task). There was no evidence to show that threat could be responded to faster by avoiding it than by approaching it (the affective mapping effect). The current results did not support the predictions, suggesting that the advantage of avoiding threat rather than approaching threat is not robust. Moreover, the reported affective mapping effects in previous studies are not all that convincing. For example, in the studies by Rotteveel and Phaf (2004), an affective mapping effect was reported in a valence judgement task. However, there were actually two different response times measured: the release time (RelT) of the home button (to start the response to the target) and the movement time (MT) needed for reaching and pushing the response button (to respond to the target images). The typical affective mapping effect was reported in the analysis of the RelT, but was not found in the analysis of the MT. In this case, there was no clear evidence that the approach/avoid behaviours triggered by arm movements influenced the task performance. However, the affective mapping effects on RelT suggested the key

pressing/releasing might be a useful tool to trigger approach/avoidance behaviour tendencies.

Apart from the affective mapping effects, there was evidence for target valence effects, namely the threatening images were responded to more slowly than the non-threatening images in the animal classification task and the threatening images were responded to faster than the non-threatening images in the threat classification task. These effects were consistent with the findings in Experiment 1, and could be well explained by the response-relevance account (Estes & Verges, 2008): threat was responded to quickly in the tasks for which valence is response-relevant and slowly in the tasks for which valence is response-irrelevant.

The target animal category effect in threat classification that occurred in Experiment 1 was also replicated in Experiment 2: cat images were responded to faster than dog images. Possibly, the cat images carried more homogeneously perceptual cues (e.g. facial structures, distinctive stripes); and these perceptual features were prioritised in processing in the threat classification task and triggered the faster responses to the cat images. However, no evidence showed that homogeneously perceptual cues facilitated responses in the animal classification task. These results indicated that the processing of perceptual features, threatening valence and the task requirements are complex. These factors may interact and, together, influence performance.

2.4. Experiment 3

The affective mapping effect was found in the RTs of releasing the home button when responding to targets (Rotteveel & Phaf, 2004), suggesting that the key pressing/releasing might be useful to trigger approach/avoidance behaviours. Key pressing/releasing was used as the approaching/avoiding response in a go/no-go task conducted by Wentura, Rothermund, and Bak (2000). As touching is a common response in approaching to a positive stimulus (e.g., touching a flower), to generate the approach behaviours participants were required to press a response key. As well as this withdrawing might be a common reaction to avoid a negative stimulus (e.g., withdrawing after an electric shock), to generate the avoidance behaviours participants were required to release the response key. In the study by Wentura et al.

(2000), two conditions were designed in the go/no-go task. In the approaching condition, participants needed to press the key as a response to the stimuli in the go trials, and no responses were required in the no-go trials. In the avoiding condition, participants needed to release the key as a response to the stimuli in the go trials, and no responses were required in the no-go trials. Results showed that responses to negative stimuli were relatively faster by key releasing; and responses to positive stimuli were relatively faster by key pressing.

Inspired by the studies of Wentura et al. (2000), Experiment 3 aimed to test the affective mapping effects in a go/no-go paradigm. The avoidance was triggered by key releasing, and the approach behaviour tendency was triggered by key pressing. In the go trials, participants were required to make a response (either key pressing or key releasing); in the no-go trials, no response was required. The same stimuli as in Experiment 2 were used in Experiment 3. Participants were instructed to finish the animal classification and threat classification tasks. It was predicted that threat would be responded to faster by key releasing than key pressing in the threat classification task; and no such difference would occur in the animal classification task.

2.4.1. Method

Apparatus and Stimuli

The stimuli were the same as in Experiments 1 and 2. The wooden response spar used in Experiment 2 was replaced by a response key connected to the E-prime response box.

Design and Procedure

The animal classification and threat classification tasks were the same as used in Experiment 3. Each task included both go trials and no-go trials. Four sessions were designed in the animal classification task: pressing the key as a response to the cat images (go trials) and no response to the dog images (no-go trials), releasing the key as a response to the cat images (go trials) and no response to the dog images (no-go trials), pressing the key as a response to the dog images (go trials) and no

response to the cat images (no-go trials), and releasing the key as a response to the dog images (go trials) and no response to the cat images (no-go trials). Four separate sessions were also designed in the threat classification task: pressing the key to respond to the threatening images (go trials) and no response to the non-threatening images (no go trials), releasing the key to respond to the threatening images (go trials) and no response to the non-threatening images (no go trials), pressing the key to respond to the non-threatening images (go trials) and no response to the threatening images (no go trials), and releasing the key to respond to the non-threatening images (go trials) and no response to the threatening images (no go trials). Each task lasted about 35 min. The order of the two tasks and the sequence of the sessions in each task was balanced across participants.

In the key pressing sessions, participants were required to press the key to start the trials. Each trial began with the 1,000 ms presentation of a centrally-positioned fixation cross, which was immediately followed by one image presented in the centre of the screen on a white background for no more than 1500 ms. Participants had to press the key when a target image appeared on the screen in the go trials, and did not press the key in the no-go trials. Visual feedback stating either ‘correct’ or ‘incorrect’ followed the presence of the images for 600 ms.

In the key releasing sessions, participants pressed the key and held it to start a trial. They waited to release the key when the target image was presented in the go trials. Once the key was released, participants needed to press it as soon as possible when the next fixation cross appeared on the screen. Participants needed to keep holding the key but not releasing it in the no-go trials. Feedback stating either ‘correct’ or ‘incorrect’ followed the presence of the images for 600 ms.

Participants

Sixteen naive participants (mean age = 20, 13 female, two left-handed) were recruited for the animal classification task. Another sixteen participants (mean age = 21, 15 female) were recruited for the threat classification task. They received either a course credit or £4. All of the participants reported normal or corrected-to-normal vision.

2.4.2. Results

2.4.2.1. Animal classification Task

The mean correct RTs of the go trials (Figure 2.8.) were analysed with a 2 (valence: threatening vs. non-threatening) x 2 (animal category: cat vs. dog) x 2 (movement: key pressing vs. key releasing) repeated measures ANOVA. The analysis revealed a statistically significant main effect of valence, $F(1, 15) = 36.8$, $MSE = 1658.9$, $p < .001$; participants responded to the threatening images more slowly than the non-threatening images (mean RTs were 624 ms and 580 ms for threatening images and non-threatening images, respectively). In addition, the valence x animal category interaction was also statistically reliable, $F(1, 15) = 7.5$, $MSE = 417.9$, $p < .05$. The mean RTs were 624 ms, 571ms, 624 ms and 591 ms for images of the threatening cats, the non-threatening cats, the threatening dogs and the non-threatening dogs, respectively. The HSD test revealed that the threatening cat and dog images were responded to significantly slower than the non-threatening cat and dog images. Also, the non-threatening cat images (571 ms) were responded to faster than the non-threatening dog images (591 ms). There was no evidence that threat was responded to faster by key releasing than by key pressing.

The error rates of the go trials and no-go trials were analysed separately. For the go trials, a statistically significant main effect of movements was revealed, $F(1, 15) = 5.6$, $MSE = .023$, $p < .05$; participants responded to images more accurately by key pressing than key releasing (the error rates were 1.9% and 3.4% for key pressing and key releasing, respectively). Also, the main effect of animal category was statistically significant, $F(1, 15) = 12.2$, $MSE = .014$, $p < .01$; the error rates were 4.5% and 1.8% for cat images and dog images, respectively). There was also a statistically significant main effect of valence, $F(1, 15) = 11.7$, $MSE = .027$, $p < .01$ (the error rates were 3.8% and 4.6%, for threatening images and non-threatening images, respectively).

The error analysis of the no-go trials revealed a statistically significant main effect of the animal category, $F(1, 15) = 5.4$, $MSE = .023$, $p < .05$ (the error rates were 5.9% and 4.7%, for cat images and dog images, relatively); and a statistically significant main effect of the valence was also found, $F(1, 15) = 24.2$, $MSE = .045$, $p < .001$ (the error rates were 7.6% and 2.9% for threatening images and non-

threatening images, respectively). Two two-way interactions were also found to be statistically reliable. One was the movement x valence interaction, $F(1, 15) = 5.5$, $MSE = .007$, $p < .05$. The higher error rates were in the threatening trials than in the non-threatening trials in both the no-key pressing and no-key releasing conditions ($p < .05$). Another interaction was between the animal category and valence, $F(1, 15) = 12.9$, $MSE = .025$, $p < .01$. The HSD test did not reveal any further statistically significant effects.

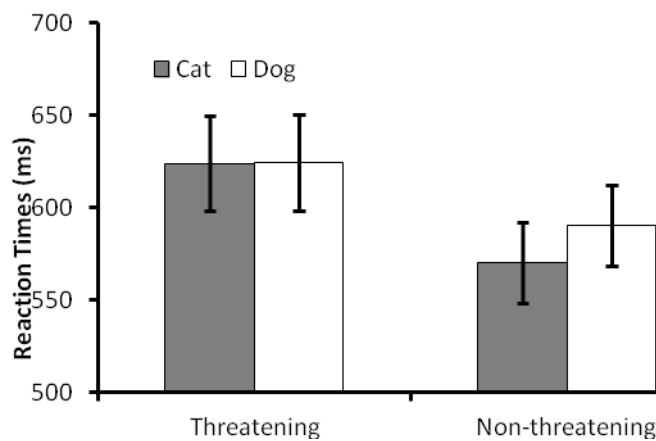


Figure 2.8. Mean reaction times for threatening cats, threatening dogs, non-threatening cats and non-threatening dogs in the animal classification task of Experiment 3. Error bars reflect within-participants standard.

Summary

The findings in the go trials were that the threatening images were responded to more slowly than the non-threatening images. Responses to the threatening images were more accurate than those to the non-threatening images. Comparing the speed with error rates, the data reveals that participants tended to trade accuracy for speed in the threatening image trials. Aside from this there was no other systematic speed/accuracy trade-offs in the data. Moreover, results showed that motor actions influence the response accuracy. Participants responded to targets more accurately by key pressing than by key releasing. Furthermore, target animal category also influenced response accuracy. Dog images were responded to more accurately than cat images. In the no-go trials, stimuli valence influenced performance. Participants made more errors in the responses to threatening images than in those to the non-threatening images. Also, target animal category influenced performance.

Participants made more errors in the responses to cat images than in the responses to the dog images.

2.4.2.2. Threat classification task

The same RTs analysis used in the animal classification task was used with the RTs (Figure 2.9.) of the threat classification task. The analysis of RTs revealed a statistically significant main effect of movement, $F(1, 15) = 4.8$, $MSE = 4860.5$, $p < .05$. Participants responded to the images faster by key pressing than key releasing (mean RTs were 496 ms, and 523 ms for the key pressing responses and the key releasing responses, respectively). The valence effect was also statistically significant, $F(1, 15) = 27.2$, $MSE = 3522.9$, $p < .001$ (mean RTs were 482 ms and 537ms for the threatening images and the non-threatening images, respectively). A main effect of animal category was found to be statistically reliable as well, $F(1, 15) = 17.9$, $MSE = 635.4$, $p = .001$. Cat images were responded to faster than the dog images (mean RTs were 500 ms and 519ms for the cat images and dog images respectively).

With regard to the error rates, for the go trials, the error analysis revealed that only the main effect of movement was statistically significant, $F(1, 15) = 6.9$, $MSE = .003$, $p < .05$. The mean error rates were 0.8% and 1.8% for the key pressing and key releasing responses, respectively.

The analysis of error rates from the no-go trials found more complex effects. Three main effects were found to be statistically reliable: the effect of movement, $F(1, 15) = 4.7$, $MSE = .007$, $p < .05$ (the error rates were 2.7% and 4.2% for no-key pressing and no-key releasing, respectively), the effect of valence, $F(1, 15) = 9.9$, $MSE = .004$, $p < .01$ (the error rates were 4.3% and 2.7% for threatening images and non-threatening images, respectively), and the effect of animal category, $F(1, 15) = 11.7$, $MSE = .003$, $p < .01$ (the error rates were 2.7% and 4.2% for cat images and dog images, respectively). In addition, the two-way interaction of movement x valence was statistically reliable, $F(1, 15) = 4.7$, $MSE = .002$, $p < .05$; and the three way interaction of movement x valence x animal category was also statistically significant, $F(1, 15) = 6.7$, $MSE = .002$, $p < .05$. The HSD test did not reveal any further statistically significant effects.

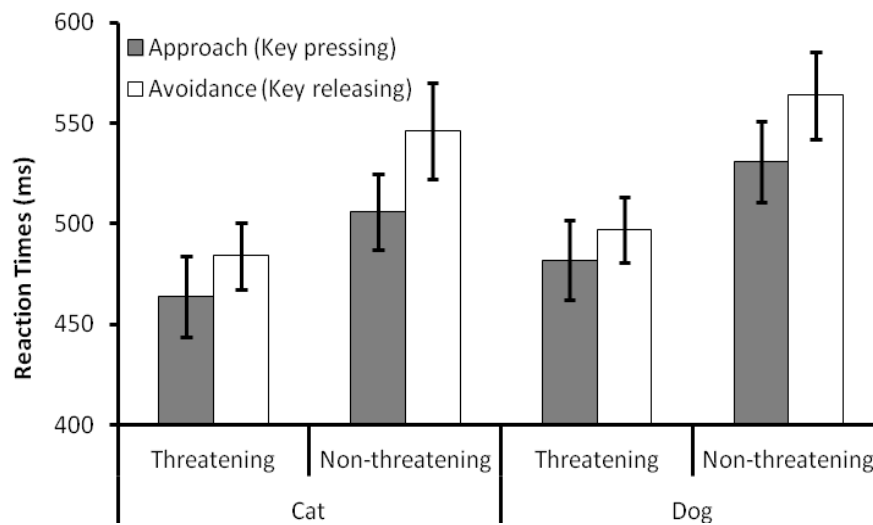


Figure 2.9. Mean reaction times for threatening cats, threatening dogs, non-threatening cats and non-threatening dogs in the threat classification task of Experiment 3. Error bars reflect within-participants standard errors.

Summary

The findings in the go trials were that participants responded to the threatening images faster than the non-threatening images. In addition, participants responded to the cat images faster than the dog images – these results were consistent with the findings in Experiments 1 and 2. Furthermore, participants responded to the stimuli faster and more accurately by pressing the key than releasing the key. There was no evidence of speed-accuracy trade-offs in the data. The findings in no-go trials were that participants made more errors by releasing the key than by pressing the key. In other words, when no responses were required, participants released the key more often than pressed the key. Participants made more errors in the responses to the threatening images than responses to the non-threatening images. Participants made more errors in the responses to the dog images than the cat images.

2.4.3. Discussion

Results from the go trials, in which participants need to make a response; and from the no-go trials, in which participants were required not to respond, are discussed separately. Starting with the results from the go trials, the major interest was to explore the relationship between threat processing and motor actions. In the

current experiment, there was no evidence to show that the threat was responded to faster by avoiding it (key releasing) than approaching it (key pressing). The reason for the null finding may be that there were other factors essential for the affective mapping effect. For example, Wentura et al. (2000) claimed that the ‘relevance’ was also the key factor of the affective mapping effects. In their studies, stimuli were the emotional words describing the social environment (e.g., cruel, sympathetic, depressed, creative, slow). The word stimuli were classified as possessor-relevant (those describing negative or positive self-recognition) or other-relevant (those signalling a potentially dangerous or safe social environment). The affective mapping effects were only found with the presence of the other-relevant words, but not with the possessor-relevant words. Wentura et al. (2000) explained the findings in terms of competing pathways: Features of a stimulus automatically trigger their respective pathways. Similar patterns of activation lead to facilitation effects, whereas dissimilar patterns of activation lead to interference. The strength of the pathway leading from perception to approach or avoidance tendencies is higher for other-relevant than for possessor-relevant words, therefore the affective mapping effect occurred in the other-relevant but not in the possessor-relevant conditions. It is possible that the stimuli used in the current experiments can evoke equally strong effects on both pathways, therefore no significant difference overall between responses to the threatening and non-threatening images occurred.

Although no affective mapping effects were found, there was an effect due to the key pressing/key releasing. In the present experiment, responses were faster by key pressing than by key releasing in both threatening and non-threatening cases (in the threat classification task only). This result was also found by Wentura et al. (2000): in the possessor-relevant condition, key pressing was faster than key withdrawing to both negative and positive words. However, they did not give any explanation for this. Maybe future studies can show more relevant results to interpret this finding.

Apart from the effects generated by motor actions, there were several target effects. In the threat classification task, cat images were responded to faster than dog images. This may be due to the fact that cat images carried more homogenous cues than dog images, and were easier to be classified in the valence judgement task.

Target valence effects were also found to occur in the threatening images, which were responded to more slowly than the non-threatening images in the animal classification task, but faster than the non-threatening images in the threat classification task. These target valence effects occurred consistently in Experiments 1-3, and showed the processing of threat was task-dependant. Threat seemingly facilitates performance when valence is response-relevant, and impairs performance when valence is response-irrelevant. No other effects were found from the responses in the go trials.

Effects in the no-go trials were based on the error rates analysis. Higher error rates were found in responses to threatening images than responses to non-threatening images, indicating that a control action of 'no responses' was impaired in the threatening trials. One explanation was the freezing account: the reason for the impairment of task performance was that motor activities are suppressed upon presentation of negative stimuli (e.g., Algom et al., 2004). The freezing account was supported by a variety of studies. For example, Wilkowski and Robinson (2006) presented emotional pictures as primes prior to the dot slides. Participants were required to indicate whether one or two dots were presented. The RTs to dots following negative stimuli were slower than RTs following neutral primes; and the RTs to dots following positive stimuli were not significantly different than baseline. As the findings in no-go trials lead to the question as to whether threat inhibits motor behaviour, the next experiment was to explore this issue and to test the freezing account.

2.5. Experiment 4

Previous studies have suggested that negative stimuli could cause the temporary freezing of all ongoing activity (e.g., Algom et al., 2004; Flykt, 2006; Öhman, et al., 2001). Experiment 4 aimed to test this motor freezing account. A go/no-go task was used, as this paradigm implicates stimulus discrimination, response selection, motor preparation, response inhibition, and error monitoring (Verbruggen & De Houwer, 2007). According to the freezing account, the responses to the threatening images will be impaired: in the go trials (participants are required to make responses), RTs following the threatening images will be slowed down; in the no-go trials

(participants are required not to respond), there will be higher error rates in responses to the threatening images than responses to the non-threatening images.

2.5.1. Method

Apparatus and Stimuli

The animal stimuli used in Experiments 1-3 were used in Experiment 4. All pictures were 12 cm (wide) x 10.5 cm (high). Targets were the symbols “#” and “@”, which were presented in black in the middle of a white frame measuring 12.5 cm (wide) x 11 cm (high). E-prime was used to run the experiment. A response key was connected to the E-prime response box.

Design and Procedure

Participants received written instructions informing them that they would see an image of an animal followed by a symbol. They were told that only the symbol was important and were asked to press the key after seeing Symbol A (either “#” or “@”, counterbalanced across participants). Participants were not required to make any response when Symbol B (either “@” or “#”) appeared. The experiment would consist of one block of 24 practice trials and two test blocks of 96 trials each. The entire task took about 20 min.

Each practice and test trial started with the presentation of the white rectangle in the centre of the black screen for 500 ms, followed by one of the images appearing in the centre of the square. After 250 ms, a symbol appeared in the middle of the screen until the participant responded or 400 ms elapsed. A feedback of ‘correct’ would appear on the screen when the participants made the right response in the go trials, and made no response in the no-go trials. A feedback of ‘too slow’ appeared on the screen if participants did not respond within 400 ms in the go trials; and a feedback of ‘error’ appeared on the screen if the participants did not press the key in the go trials or press the key in the no-go trials. The feedback display remained for 200 ms. The next trial started after an inter-trial interval of 600 ms. Go and no-go trials were intermixed, and were determined randomly for each test block and for each participant separately.

Participants

Sixteen naive participants (mean age = 21, 12 female) were recruited from students at York University. There was one left-handed individual. They received either course credit or £4. All of the participants reported normal or corrected-to-normal vision.

2.5.2. Results

The mean correct RTs were analysed with a 2 (valence: threatening vs. non-threatening) x 2 (animal category: cat vs. dog) repeated measures ANOVA. No statistically significant effects were found.

The same analysis was used for error rates. For the go trials, there were no statistically significant effects. For the no-go trials, a two-way interaction between the valence and animal category was found to be statistically significant, $F(1, 15) = 5.9$, $MSE = .002$, $p < .05$ (the error rates were 4.8%, 5.3%, 5.9%, and 3.9% for the responses to symbols following threatening cat images, non-threatening cat images, threatening dog images and non-threatening dog images, respectively; see Figure 2.10.). An HSD test did not reveal any further statistically significant reasons for the interaction.

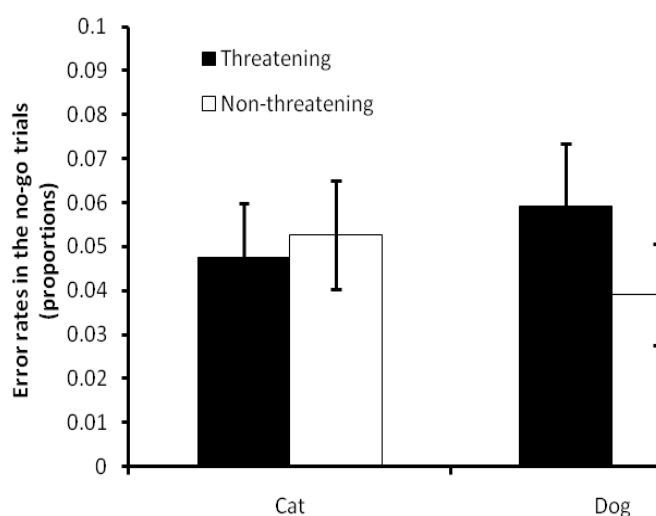


Figure 2.10. Error rates in the no-go trials (proportions) in Experiment 4.

2.5.3. Discussion

In the go trials, RTs to symbols following the threatening stimuli were not significantly different than the RTs following non-threatening stimuli. In the no-go trials, there was no significant difference of error rates in responses to threatening or non-threatening images. The current results, therefore, do not support the claim that threat inhibits motor actions. One explanation for the negative findings was that negative valence may not be relevant to motor inhibition at all. For example, Verbruggen and De Houwer (2007) examined the impact of emotional stimuli on performance during a stop-signal task, in which participants are required to perform a simple speeded response task, but to refrain from responding when a stop signal (a tone) is presented immediately after the target. The findings were that the presentation of highly arousing emotional stimuli (but not the valence of the stimuli) interfered with both responding to the targets and stopping. De Houwer (2007) and De Houwer and Tibboel (2010) claimed that arousal, but not negative valence, was the reason for motor inhibition.

2.6. General Discussion

Different paradigms were used in Experiments 1-4. The threats were presented in the centre of the screen, either as the targets (in Experiment 1-3) or as the primes (in Experiment 4). The responses to the targets (images of cats and dogs in Experiment 1-3, images of symbols in Experiment 4) varied according to the task, involved non-motor-related responses (Experiment 1), motor actions (Experiments 2-3), and motor inhibition (Experiment 4). The consistent results in the four experiments were that: 1) the threat slowed down performance in the animal classification task (Experiments 1-3); 2) participants responded faster to the threatening stimuli than non-threatening stimuli in the threat classification task (Experiments 2-3, but only in the cat trials in Experiment 1); 3) the cat images were responded to faster than the dog images in the threat classification tasks (Experiments 1-3).

The results showed that the task requirements influenced threat processing. According to the response-relevance account (Estes & Verges, 2008), threat slowed down responses when it was irrelevant to task requirement; and facilitated the

responses when it was relevant to task requirement. This account was well supported by the findings in the animal classification and threat classification tasks (Experiments 1-3), in which threat was presented as targets. However, no supporting evidence was found when threat was presented as a prime but not a target (in Experiment 4). Possibly, task requirements can influence threat processing in the condition that threat is required to be processed. When threat is presented as a target, stimuli valence is processed as required and its effects are task-dependent. When threat is presented as a prime, no processing was required, and any effects caused by prime valence are task-independent.

Moreover, the cat images were responded to faster than dog stimuli in the threat classification task, and this effect was replicated in Experiments 1-3. One of the possibilities is that cat images carried more homogenously visual cues than dog images, and those cues facilitated the responses to the cat images. However, this cat classification advantage did not occur in the animal classification task. The results above indicated a complex interaction among the processing of task requirements, threatening valence and perceptual cues.

To explore the relationship between motor actions and threat processing, the approach/avoidance responses were triggered by arm movement (in Experiment 2) and finger movement (in Experiment 3). In prior research (e.g., Rotteveel & Phaf, 2004), participants were found to respond to threats faster when avoiding them than approaching them in the valence judgement task, but not in the non-valence task. As opposed to the previous findings, the results in the current threat classification tasks did not reveal any association between the avoidance behaviours and threat processing. Possibly the arm and finger movements were too weak to trigger the approach/avoidance tendencies in the presence of the animal stimuli. When facing biological threats, escaping as fast as possible is one of the natural reactions to a tiger or a wolf. This kind of whole body movement rather than arm or finger movements may be associated with approaching/avoiding much stronger. In future studies, body movements can be considered as required responses to the presence of biological threats.

In conclusion, the responses to threat are flexible. There was evidence that the responses to threatening targets were task-dependant. The threat facilitates the performance if relevant to the task requirements, and interferes with performance if irrelevant to the task requirements. There was no clear evidence for the responses

following presence of threatening stimuli (threatening primes). The affective mapping effect, avoiding threat is faster than approaching to it, did not occur in the current experiments. These findings will be discussed in more detail in Chapter 5.

Chapter 3 Threat processing and spatial attention

3.1. Introduction

Over the past 30 years a large body of research has been carried out on visual attention to threat. Empirical evidence has been found that threat can capture attention rapidly and automatically (e.g., Esteves, Dimberg, & Öhman, 1994; Fox et al., 2000; Öhman, et al., 2001; Öhman, Lundqvist, & Esteves, 2001); and also that threat can modulate the engagement of attention (Fox, et al., 2001, 2002; Tipples & Sharma, 2000; Yiend & Mathews, 2000; Koster, Crombez, Van Damme, Verschuere, & De Houwer, 2004). Attentional biases to threat suggest enhanced processing of emotional stimuli. Although the cognitive system is assumed to process emotional content with minimal attentional demands, the level at which emotion and attention interact and how they do so is unclear (Phelps, Ling, & Carrasco, 2006).

The main issue in this chapter is that of how visual threat captures attention when it is presented in the foveal visual field (i.e., at fixation), as well as outside the current focus (in the parafoveal visual field, i.e., more than 2.5° of visual angle from fixation, Wandell, 1995). The flanker task (Eriksen & Eriksen, 1974) provides a useful tool to study the modulation of attention to a particular object or location. In standard flanker tasks the positions of all stimuli are typically known in advance. In each display one central target stimulus and two or more non-target stimuli are presented as so-called flankers either side of the target. Participants are instructed to make a speeded judgement about the nature of the target. In the standard flanker task, response times (RTs) are usually faster and more accurate when the flankers and the target are either identical or are assigned to the same response (i.e., they are *compatible*) than when the flankers and target are different/are assigned to different responses (i.e., they are *incompatible*). This pattern of results will be referred to as the *flanker compatibility effect*. The flanker compatibility effect not only reflects response competition, but also indicates a failure of selective attention. It arises because of a failure to selectively ignore the flankers.

This flanker paradigm has been used to explore the processing of emotional targets and flankers. In flanker experiments of Fenske and Eastwood (2003; Experiment 1A) a target (i.e., a positive or negative face) was presented in the centre of the display until the participant classified the expression of the face. Flanking faces, expressing positive, negative or neutral expressions were used and “no-flanker” trials provided a measure of baseline performance (see Figure 3.1.). A key

finding was that participants responded to positive targets faster with compatible flankers than with incompatible flankers – there was a reliable flanker compatibility effect. However, no flanker compatibility effect was found in the RTs to negative targets, responses to negative targets were not affected by the presence of incompatible flankers.

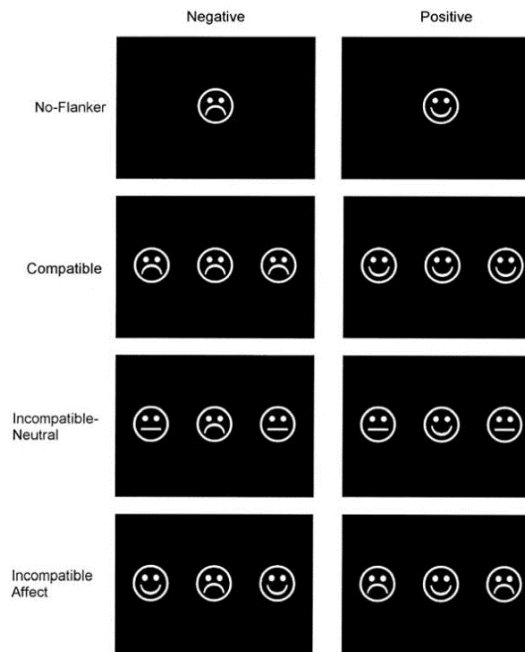


Figure 3.1. Examples of the stimulus displays used in studies of Fenske and Eastwood (2003; Experiment 1A).

Fenske and Eastwood (2003) put forward two possible explanations for the results. The first was that negative target facial expressions narrow attention and hence restrict the processing of peripheral (flanker) information. The second was that the negative targets had no effect on attention, but rather the positive targets widened the participant's attention. To test these possibilities they conducted another experiment (in Experiment 2) which included testing targets with neutral facial expressions. The results were that flanker compatibility effects were found in the neutral and positive target cases, but not in the negative ones. Furthermore, the magnitude of the flanker compatibility effect was found to be greater in the positive target trials than in the neutral target trials. Consequently, the conclusion was that the emotional content of the target influences the breadth of attention. Negative targets

constrict attention, hence the possible influence of the flankers is reduced, whereas positive targets lead to the widening of the attentional focus.

The current study aims to test the generality of flanker effects. In a series of flanker experiments (see Table 3.1.), the exploration of the relationship between the processing of targets in the central visual field and the processing of flankers in the peripheral visual field provided useful information to answer the question about how peripheral threat is processed.

Table 3.1.

A summary table of the designs of Experiments 5-9.

Experiment	Stimuli	In each stimuli display	Tasks
5	Greyscale images of one threatening cat, one threatening dog, one non-threatening cat, one non-threatening dog	One target and flankers were presented simultaneously	Animal classification, Threat classification
6	Coloured photographic images of threatening cats, threatening dogs, non-threatening cats, non-threatening dogs. 24 images for each type of animal selected as the targets, and 16 images for each type of animal selected as the flankers	One target and flankers were presented simultaneously	Same as Experiment 5
7	Same as Experiment 6	Flanker images were presented prior to the presence of the target	Same as Experiment 5
8	Same as Experiment 6	Flanker images were enlarged and were presented prior to the presence of the target	Same as Experiment 5
9	Same as Experiment 6	Targets and flankers were presented simultaneously	Location judgement

3.2. Experiment 5

One concern with the work with schematic faces is that effects may not be due to actual facial emotion but perceptual features. For instance, the proximity of the down-turned mouth to the line delineating the perimeter of the face in the negative schematic face could cause an appearance of a closed structure, which does not exist in either the neutral or happy faces. This may be the reason for the effects which were claimed to be due to negative valence (Mak-Fan, Tompson, Green, &

Robin, 2011). Therefore, actual photographic images of biological threats were used, as the attention can be captured automatically if stimuli related to recurrent survival threats (Tooby & Cosmides, 1990; Öhman & Mineka, 2001). Following on from the previous chapter we chose to use images of threatening cats, threatening dogs, non-threatening cats and non-threatening dogs.

Two tasks were used in the experiment. In the first task – the animal classification task – participants simply classified the target as a cat or a dog. In the second task – the threat classification task – participants classified the target as being threatening or non-threatening. Exactly the same experimental design and stimuli were used in both tasks. In both tasks if the valence of the flankers is automatically detected then target responses should be influenced by this.

Several kinds of target and flanker effects could be examined in the above tasks: The classic flanker compatibility effect, in which the responses to the target are influenced by the nature of the flankers. Concerned with the two different task requirements, there may be two different kinds of flanker compatibility: (i) the animal congruency effect – do the target and flanker images depict instances of the same biological category? And (ii) the emotional congruency effect – do the target and the flankers depict instances of the same emotional valence? In addition the general effects of targets and flankers were also examined : (1) *the target valence effect* – are threatening targets responded to more slowly and/or less accurately than the non-threatening targets; and (2) *the target animal category effect* – are there differences in performance with the cat and dog targets. Finally, we may also question whether performance will vary according to the type of flankers – are there corresponding flanker valence and flanker animal effects?

3.2.1. Method

Apparatus and Stimuli

E-prime (Schneider, Eschman, & Zuccolotto, 2002) running on a Windows 2000 PC, was used for controlling the experiment. In addition, an E-prime response box was used to collect the responses. Keys 1 and 2 were used throughout. All experimental stimuli and instructions were presented on a 15" SONY monitor (model CPD-100ES).

Four images were selected as the critical stimuli. The respective images were of a threatening dog, a threatening cat, a non-threatening dog and a non-threatening cat. An image of a rug pattern was chosen as a neutral stimulus (i.e., image 7179 taken from the International Affective Picture System, IAPS). The individual pictures were sourced from various Internet searches and modified with Photoshop and stored as 150 x 113 pixel bitmaps. In the experiment each stimulus subtended 2.7° of visual angle in height and 2.0° in width (see Figure 3.2.). All images were rendered in greyscale format.

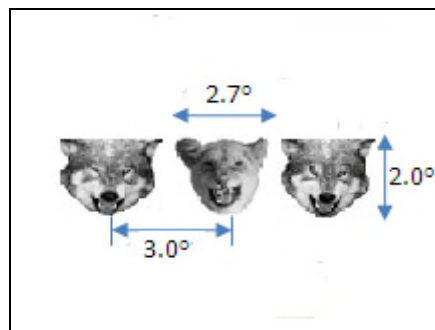


Figure 3.2. An example of the stimuli display in Experiment 5.

Design

Six basic conditions reflected the factorial combination of animal congruency (incongruent and congruent) and emotion congruency (incongruent and congruent), together with a neutral flanker condition and a condition in which no flankers were present. The data from the neutral flanker and no flanker conditions provided useful indications of baseline performance.

The experiment was divided into five blocks, each comprising four repetitions of 24 stimulus configurations resulting from a combination of the target conditions with the flanker conditions. The experimental blocks were preceded by a 24 trial practice block with the same design. Between the blocks participants were allowed to pause.

Two classification tasks were tested in different blocks of trials in the experiment and the same stimuli were used in both tasks. In the animal classification task participants were instructed to judge whether the target was an image of a dog or a cat. In the threat classification task participants were instructed to judge whether the target was an image of a threatening or a non-threatening animal.

Participants

Twenty-eight naive participants (mean age = 21, 24 female) were recruited from students at York University. There were three left-handed individuals. They received either course credit or £2. All of the participants reported normal or corrected-to-normal vision.

Procedure

Participants were tested in a quiet, windowless cubicle and sat at a table in front of a chin rest situated 57 cm from a computer screen which was located on a raised plinth. The centre of the screen was at eye-level. On the table in front of the screen was placed the E-prime button box. The screen and response box were linked to a PC computer situated outside the cubicle.

Written instructions were presented first to explain the task and the stimuli. Participants were carefully instructed on all aspects of the task. The instructions urged the participants to react quickly and accurately to the target image. Half of the participants were tested on the animal classification task first. For the other half of the participants the order of testing was reversed.

Each trial began with the 1,000 ms presentation of a centrally-positioned fixation cross, which was immediately followed by the stimulus display. The stimuli were presented on a white background. The target stimulus was presented at the centre of the screen, and when the flankers were presented one image occurred to the left and one image occurred to the right of the target. The flankers were centred at 3.0° eccentricity. The stimulus remained on the screen until a response had been made. RTs were measured from the onset of the stimulus display. A feedback display (either “Correct” or “Error”) was presented after a response for 300 ms. Both tasks were completed in a single testing session lasting approximately 35 mins.

3.2.2 Results

The analysis of results was, firstly, carried out on the critical flanker conditions (the factorial combination of animal congruency: incongruent and congruent; and emotion congruency: incongruent and congruent), and then

subsidiary analyses were carried out on the no flanker condition and the neutral flanker condition.

3.2.2.1 Animal classification task

The analysis of the critical flanker conditions

The mean correct RTs were analysed with a 2 (target valence: threatening vs. non-threatening) x 2 (target animal: cat vs. dog) x 2 (emotion congruency: incongruent vs. congruent) x 2 (animal congruency: incongruent vs. congruent) repeated measures ANOVA.

The analysis revealed statistically significant main effects of target valence, $F(1, 27) = 9.3$, $MSE = 5622$, $p < .01$ (mean RTs were 636 ms and 614 ms for threatening target images and non-threatening target images, respectively); and a statistically significant main effect of animal congruency, $F(1, 27) = 16.6$, $MSE = 499$, $p < .001$ (mean RTs were 629 ms and 621 ms for animal incongruent trials and animal congruent trials, respectively). In addition, the two-way interactions were also statistically reliable: the target valence x target animal interaction, $F(1, 27) = 14.6$, $MSE = 2941$, $p = .001$; and the emotion congruency x animal congruency interaction, $F(1, 27) = 8.1$, $MSE = 2151$, $p < .05$.

These two-way interactions were analysed further using Tukey's HSD tests ($\alpha = .05$). For the interaction between target valence and target animal, the HSD test revealed that participants responded to the threatening cat targets more slowly than to the nonthreatening cat targets; but there was no valence effect revealed in dog target trials (the mean RTs were 647 ms and 605 ms for the threatening and non-threatening cats, respectively; the mean RTs were 625 ms and 623 ms for the threatening dog and non-threatening dog targets, respectively; see Figure 3.3.).

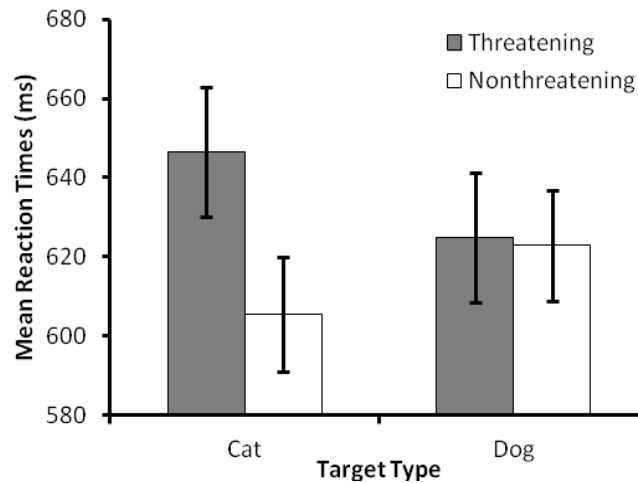


Figure 3.3. Mean reaction times for threatening cats, threatening dogs, non-threatening cats and non-threatening dogs in the animal classification task of Experiment 5. Error bars reflect within-participant standard errors.

For the interaction between emotion congruency and animal congruency, the effect of animal congruency only arose for the emotionally congruent displays (see Figure 3.4.). RTs were longer for the animal incongruent than the animal congruent cases (mean RTs were 634 ms and 613 ms, respectively). The corresponding mean RTs were 625 ms and 629 ms for the emotionally-incongruent cases.

This interaction arose because of the relatively speeded responses to the emotionally-congruent/animal congruent displays (however, the only statistically reliable difference arose for the emotionally-congruent cases, all other $ps > .05$). In this experiment, as stimuli were repetitively selected as targets and flankers, the emotionally-congruent/animal congruent displays contained the identical flankers and targets. The animal congruency effect was revealed only when identical targets and flankers were presented: this is the typical flanker compatibility effect.

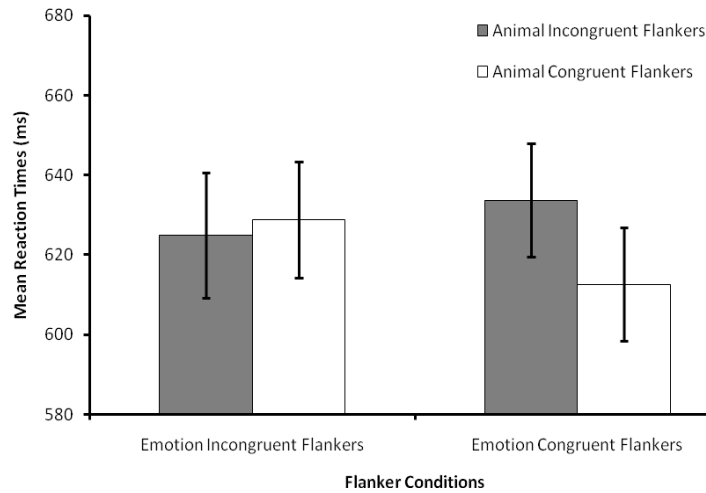


Figure 3.4. Mean reaction times in emotion incongruent/congruent and animal incongruent/congruent flanker conditions in the animal classification task of Experiment 5. Error bars reflect within-participant standard errors.

Error rates in this experiment were low with the maximum score being 6% across all conditions. The ANOVA used on the RTs was used on the transformed error scores. This analysis only revealed a statistically significant main effect of target animal, $F(1, 27) = 6.4$, $MSE = 0.01$, $p < .05$. Participants were more accurate in classifying the dog target images than the cat target images. No other tests were statistically reliable. There was no evidence of any systematic speed/accuracy trade-offs in these data.

Summary

Participants responded to the threatening targets more slowly than to the non-threatening targets, which is an example of the target valence effect, target threat impaired task performance. The target valence effect occurred in the cat target trials, but did not generalize to the dog target trials. Maybe the cat images carried more salient threat cues (i.e., the distinctive stripes) than the dog images; and the stronger threatening cues in cat images impaired task performance. Apart from the target valence effect, there is a fast same effect (e.g., Farrell, 1985) – RTs for the same stimulus pairs (in which the targets and flankers are identical images) are shorter than those for different stimuli pairs (in which the targets and flankers are different images). This possibility is discussed in more detail later.

The analysis of neutral flanker/no flanker conditions

It is worth exploring whether participants responded to target images equally fast without any flankers and how much the presentation of the flankers induced a RT cost. The second analysis used the RTs from the neutral and no-flanker conditions to reveal the answers. A 2 (target valence: threatening vs. non-threatening) x 2 (target animal: cat vs. dog) x 2 (flanker presence: neutral flanker vs. no flanker) repeated measures ANOVA revealed a statistically significant main effect of flanker presence only, $F(1, 27) = 22.1$, $MSE = 1635$, $p < .001$. Participants responded to no flanker trials faster than neutral flanker trials (mean RTs were 598 ms, and 624 ms, respectively). The analysis of transformed error scores of neutral flanker and no-flanker conditions did not reveal any statistically significant effects. There was no evidence of any systematic speed/accuracy trade-offs in these data.

Summary

The results from the comparison between the neutral and no flanker conditions showed that participants responded to the four types of stimuli (threatening cats, threatening dogs, non-threatening cats and non-threatening dogs) equally fast. Also, participants responded to the targets faster when they were presented alone than when they were with neutral flankers.

3.2.2.2 Threat classification task

The analysis of the critical flanker conditions

The same sorts of analyses that were used on the data for the animal classification task were used in the threat classification task.

The analysis of the RTs only revealed a statistically significant four-way interaction: target valence x target animal x emotion congruency x animal congruency, $F(1, 27) = 5.7$, $MSE = 1130$, $p < .05$. In order to examine the reliable four-way interaction in more detail, separate three-way ANOVAs were carried out on the data from the cat and dog target trials. No statistically significant effects were found in the data from the cat trials. For the dog trial data, however, the only statistically reliable test was for the three-way target valence x emotion congruency x animal congruency interaction, $F(1, 27) = 5.2$, $MSE = 1330$, $p < .05$. Further

analyses were carried out separately for the threatening dog and non-threatening dog trials. No more statistically significant effects were revealed. However, the interaction may have arisen because of a reversed animal congruency effect in the non-threatening dog trials. There was no clear reason for this.

Error rates in this experiment were low. The maximum score was 5% across all conditions. The same ANOVA was used on the transformed error scores as was used on the RTs. No statistically reliable tests reached any statistical significance (all $ps > .05$). There was no evidence of any systematic speed/accuracy trade-offs in these data.

Summary

There were neither target effects nor flanker effects in this experiment.

The analysis of neutral flanker/no flanker conditions

The ANOVA of the RTs from the neutral and no-flanker conditions was the same as in the animal classification task. The analysis only revealed a statistically significant main effect of flanker presence, $F(1, 27) = 10.828$, $MSE = 1871.89$, $p < .01$ (mean RTs were 523 ms and 542 ms for the no flankers and neutral flanker conditions, respectively). No statically significant effects were revealed in the error analysis. There was no evidence of any systematic speed/accuracy trade-offs in these data.

Summary

Participants responded to the targets faster when they were presented alone than when they were with neutral flankers; this result was the same as that in the animal classification task.

3.2.3 Discussion

Target effects

The main findings were that in the animal classification task, participants responded to the threatening targets more slowly than to the non-threatening targets;

target threat slowed down task performance. This was the target valence effect and was also found in the animal classification task in Chapter 2. The target valence effect can be explained in terms of response relevance: the threatening target captured attention when it was presented in a display. Threat was task-irrelevant in the animal classification task and attention needed to be disengaged from target valence to other task relevant information, for instance, the categorical information of cats and dogs. Attention can be held longer by the threatening targets than by the non-threatening targets and was more slowly disengaged from threat than from non-threat. Therefore, slower responding to threat was evoked and the threatening targets were generally responded to more slowly than the non-threatening targets. In the current experiment the target valence effect only occurred in the data from the cat target trials, but not in the data from the dog target trials. Possibly, selected cat images carried more homogenous cues than the dog images, and these cues facilitated responses to cat images.

The flanker effects

Apart from exploring how threatening targets influence responses, another main point of interest was to address how flankers influence performance. Comparing the results from the neutral and no flanker conditions, the findings were that participants responded to the targets faster when they were presented alone than when they were with neutral flankers; this is the evidence that flankers slowed down performance. However, the main aim was to understand how flanker conditions of emotion and animal congruency influenced the responses to the targets. The only reliable flanker effect was the fast same effect in the animal classification task: participants responded to the targets with identical flankers faster than with different flankers.

The fast same effect has been primarily found in same-different judgment tasks (e.g., Farrell, 1985). Although there is a variety of same-different judgement tasks, in a typical version (e.g., Nickerson, 1972) the target stimulus and test stimulus are successively presented for comparison on each trial, whereas in certain other cases the target-test stimuli are presented simultaneously. Across trials the same and different stimulus pairs occur in an equal probability. In the current

experiment speeded responses seemed to indicate that some form of crude representation of the flankers and target is generated that captures the fact that all of the stimuli are physically identical. Farrell (1985) reviewed same-different judgment tasks in past decades and summarised that dual-process models as well as single-process models were developed to explain the fast same effects. The dual-process models assume 'same' and 'different' judgements are parallel comparison operations and the identity reporter (Bamber, 1969) is fast and only underlies in the 'same' judgements; a slow comparator that underlies 'different' judgements. However, single-process models assume a stimulus comparison process underlying 'same' judgements also underlies 'different' judgements. The fast same effect does not arise from stimulus comparisons directly, but rather from other factors (e.g., subjects' strategies).

A question arose as to whether the flanker compatibility effect reported in previous studies (e.g. Fenske & Eastwood, 2003) was actually due to the identical perceptual attributes of the images. To answer this question, the selected stimuli sets used in the previous studies were examined carefully (see Table 3.2.). In the original reports by Fenske and Eastwood (2003), there were three images used as both targets and flankers: a positive face, a negative face and a neutral face. The flanker compatibility effects occurred in the compatible flanker conditions, in which the targets and flankers were identical positive faces. Following these pioneering studies, Horstmann, et al. (2006) used an angry, a friendly and a neutral face as stimuli. Again, the flanker compatibility effects were replicated in the compatible conditions, in which the targets and flankers were identical friendly faces.

Most of the flanker compatibility effects were found in the emotion-version of flanker experiments (e.g., Schmidt & Schmidt, 2013) when the targets and flankers were identical. The reported flanker compatibility effects in these previous studies were actually fast same effect. As well as Experiment 1, a fast response that underpins the flanker compatibility effect is presumably due to the quick recovery of the identical presence of these images. Whether flanker compatibility effects could be due to the emotion congruency and/or animal congruency was still unclear.

Table 3.2.

A brief summary table for previous flanker experiments.

Experiments	Stimuli	Conditions	Findings
Fenske & Eastwood (2003)	A positive, a negative and a neutral schematic face	Only one target image presented in the no flanker conditions; the target and flankers were identical in the compatible conditions; the targets and flankers carried different emotions in the incompatible conditions; emotional targets were flanked by neutral faces in the incompatible neutral conditions	A flanker compatibility effect was found in the positive face target trials, but no such effect was found in the negative face target trials.
Horstmann et . al. (2006)	An angry, a friendly, and a neutral schematic face	Same as above	A flanker compatibility effect was found in the friendly face target trials, but not in the angry face target trials.
Schmidt & Schmidt (2013)	A happy and a sad schematic face	Same as above	Small but significant flanker compatibility effects were found in the happy and sad face target trials; the compatibility effects were slightly larger for the happy than for the sad target faces.
Zhou & Liu (2013)	12 faces (6 women); neutral, happy and fearful expressions for each face.	The flankers and targets were randomly selected from a pool of 12 faces. In the Emotion-Gender task, the conditions were: gender same/emotion same; gender different/emotion same, gender same/emotion different, gender different/emotion different	An emotion congruency effect was found in both the happy and fearful target trials in the emotion judgement task

3.3. Experiment 6

Most recently, a study by Zhou and Liu (2013) found evidence for the flanker compatibility effects by using a variety of facial stimuli. 12 faces (6 women) were generated as stimuli. Each face expressed three facial expressions: neutral, happy

and fearful. In their first experiment participants were required to identify the colour (full colour/greyscale) and the gender (male/female) of the central face whilst ignoring flankers; and in the second experiment participants were required to identify the emotion (happy/fearful), and gender (male/female) of the central targets. The effects of colour congruency and gender congruency were found in their Experiment 1; and the effects of emotion congruency and gender congruency were found in their Experiment 2. The flanker compatibility effect only occurred when the conflicts were task relevant, but disappeared when the conflicts were task irrelevant. For example, the emotion congruency effect was found when the emotion was task relevant (in the emotion identification task) and disappeared when it was task irrelevant (in the gender identification task).

Zhou and Liu (2013) provided evidence that the flanker compatibility effects could occur when targets and flankers were congruent, but different. Can we find evidence for flanker compatibility effects with threatening, non-threatening animal stimuli when targets and flankers are congruent in one dimension (e.g. emotion), but different from each other? To rule out the presence of identical targets and flankers, the stimuli set size were enlarged in Experiment 6 and the targets and flankers were selected from independent stimuli pools. The same stimuli set used in Chapter 2 was used here: non-threatening dogs (i.e., dogs from domesticated breeds), threatening dogs (e.g., wolves, hyenas, attack dogs depicted in a threatening disposition), non-threatening cats (i.e., cats from domesticated breeds) and threatening cats (i.e., wild cats - lions, tigers, panthers – depicted in a threatening disposition). All threatening animals were shown snarling towards the viewer. The same tasks were used in Experiment 6 as in Experiment 5. The animal congruency effect was predicted to occur in the animal classification task and the emotion congruency effect was predicted to occur in the threat classification task.

3.3.1. Method

Stimuli

The stimuli were the same as used in Chapter 2.

Design

The same basic conditions as used in Experiment 5 were used here. The experiment was divided into six blocks. Across trials within each block there was no repetition of either a target image or flanker images. Images were repeated across the blocks. The experimental blocks were preceded by a 24-trial practice block with the same design. Between the blocks, participants were allowed to pause. The same two classification tasks were tested in this experiment as in Experiment 5. In both tasks the same stimuli were used.

Participants

Eighteen naive participants (mean age = 20, 2 male) were recruited from students of York University. There were two left-handed individuals. They received either a course credit or £4. All of the participants reported normal or corrected-to-normal vision.

Procedure

The procedure was the same as in Experiment 5.

3.3.2 Results

3.3.2.1 Animal classification task

The analysis of the critical flanker conditions

The same method of analysis used on the data for the animal classification task in Experiment 5 was used here. The analysis of the RT data from the critical flanker conditions revealed a statistically significant main effect of target valence, $F(1, 17) = 33.9, MSE = 7015, p < .001$ (mean RTs were 761 ms and 703 ms for threatening target images and non-threatening target images, respectively; see Figure 3.5). Overall, responses to the threatening targets were slower than responses to the

non-threatening targets. This is a clear target valence effect. No other tests reached statistical reliability.

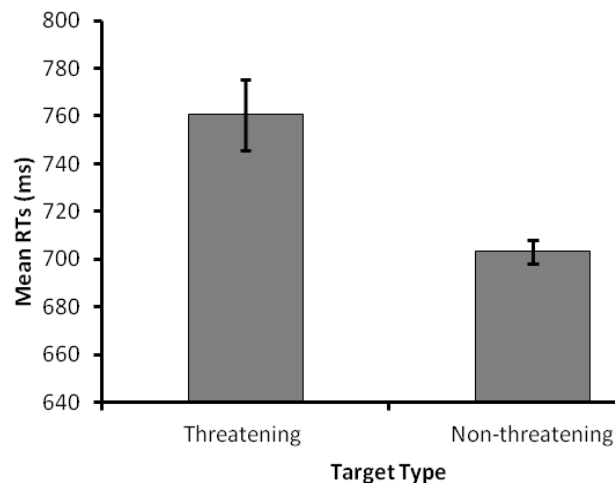


Figure 3.5. Mean reaction times (RTs) for the threatening, non-threatening targets in the animal classification task of Experiment 6.

Error rates in Experiment 6 were generally higher than in Experiment 5. This may be due to the increased number of selected stimuli. The processing of more complex pictures reduced the response accuracy. Analysis of the transformed error scores using ANOVA revealed a main effect of target valence, $F(1, 17) = 29.2$, $MSE = 0.08$, $p < .001$, participants classified the non-threatening images more accurately than the threatening ones. In addition the target valence x emotion congruency interaction, $F(1, 17) = 7.1$, $MSE = 0.007$, $p < .05$, and the target valence x target animal x emotion congruency, $F(1, 17) = 7.02$, $MSE = 0.03$, $p < .05$, were also statistically reliable.

To understand more fully the higher-order interaction, separate three-way ANOVAs were carried out on the data from the cat and dog target trials, respectively (Figure 3.6.). The effects in the data for the cat target trials were relatively straightforward. Only the main effect of target valence reached statistical significance, $F(1, 17) = 13.8$, $MSE = 0.12$, $p < .01$, for the data from the cat target trials. Participants responded to non-threatening items more accurately than threatening items.

For the data of the dog target trials the effects were more complex. The analysis revealed statistically significant main effects of target valence, $F(1, 17) = 6.8$, $MSE = 0.11$, $p < .05$, and animal congruency, $F(1, 17) = 9.9$, $MSE = 0.01$, p

< .01, together with a reliable target valence x emotional congruency interaction, $F(1, 17) = 9.7, MSE = 0.03, p < .01$.

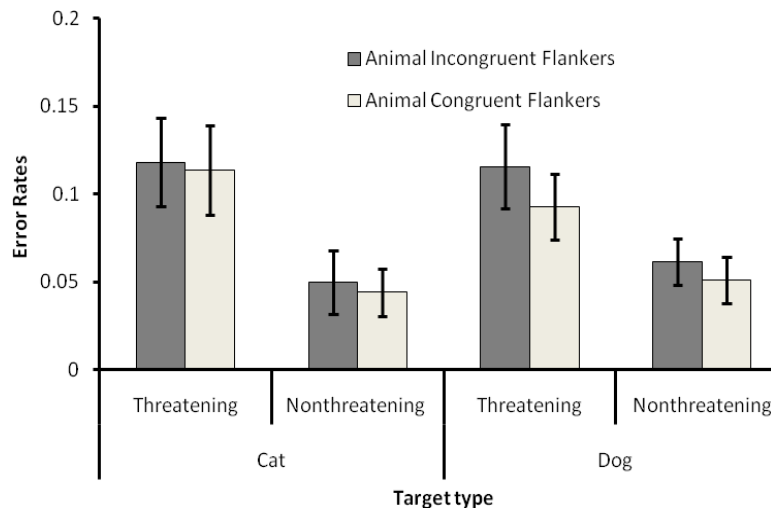


Figure 3.6. Response error rates for the targets in animal incongruent/congruent flanker conditions in the animal classification task of Experiment 6. Error bars reflect within-participant standard errors.

An HSD test was carried out to examine the interaction in more detail. What this revealed was that there was a reliable difference in accuracy across the threatening and non-threatening cases of emotionally-congruent trials. Participants were more accurate on non-threatening than threatening trials when the target and flankers portrayed the same valence ($p < .05$). However, the difference between non-threatening trials and threatening trials across the emotionally-incongruent condition did not reach statistical significance in the dog trials. There was no evidence of any systematic speed-accuracy trade-offs in the data.

Summary

The finding in the RT analysis was clear: there was a target valence effect (participants responded to threatening targets more slowly than to non-threatening targets), but the findings in the error analysis were ambiguous. Generally speaking, more errors were found in the responses to the threatening targets than to the non-threatening targets. Apart from the target effects, flanker animal congruency showed an influence on the error rates as well. Participants responded more accurately when

the targets and flankers were from the same animal category than when they were not. This animal congruency effect only occurred in the data from the dog target trials, but not in the data from the cat target trials. So, there is some evidence for the animal congruency effect, however, it only occurred in the error rates of responses in the dog target trials and was not mirrored in the RT data.

The analysis of neutral flanker/no flanker conditions

The ANOVA of RT data from neutral flanker and no flanker trials only revealed a statistically significant main effect of target valence, $F(1, 17) = 23.9$, $MSE = 7335$, $p < .001$ (mean RTs were 681 ms, and 751ms, respectively). No other test reached statistical significance.

The analysis of transformed error scores of neutral flanker and no-flanker conditions revealed only that the main effect target valence reached statistical significance, $F(1, 17) = 35.2$, $MSE = 0.04$, $p < .001$. Lower error rates were found on non-threatening target trials (5%) than on threatening target trials (11%). There was no evidence of any systematic speed-accuracy trade-offs in the data.

Summary

Participants responded to non-threatening targets faster and more accurately than the threatening ones regardless of the flanker conditions (no/neutral flankers). These results are consistent with the findings in the animal classification task from the previous chapter, in which threatening targets slowed down performance.

3.3.2.2 Threat classification task

The analysis of the critical flanker conditions

The ANOVA of RTs revealed a statistically significant main effect of target animal category, $F(1, 17) = 6.1$, $MSE = 3957$, $p < .05$ (mean RTs were 691 ms and 709 ms for cat target trials and dog target trials, respectively; see Figure 3.7). No other effects reached statistical significance.

No reliable statistically significant effects were revealed in analysis of the transformed error scores. There was no evidence of any systematic speed-accuracy trade-offs in the data.

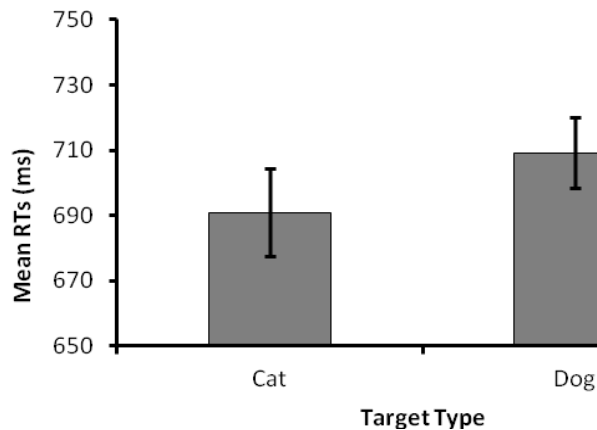


Figure 3.7. Mean reaction times (RTs) for the cat and dog targets in the threat classification task of Experiment 6.

Summary

In Experiment 6, a target animal category effect occurred, participants responded to the cat targets faster than to the dog targets. This effect was found in Chapter 2, but not in the current chapter's Experiment 5. Enlarging the stimuli set enhanced the target effect, but there was still no evidence in RTs attributable to the nature of the flankers.

The analysis of neutral flanker/no flanker conditions

The analysis of RTs from the neutral and no-flanker conditions revealed only a main effect of target animal, $F(1, 17) = 6.03$, $MSE = 3160$, $p < .05$. Cat target images were, on average, classified faster than dog target images (mean RTs were 677 ms, and 701 ms, respectively).

The analysis of transformed error scores from neutral and no flanker conditions found a main target valence effect, $F(1, 17) = 4.7$, $MSE = 0.06$, $p < .05$; and a main effect of target animal, $F(1, 17) = 5.2$, $MSE = .04$, $p < .05$. Participants were more accurate in their responding to non-threatening targets than threatening targets. In addition they were more accurate in responding to cat targets than dog targets. There was no evidence of any systematic speed-accuracy trade-offs in the data.

Summary

The responses to the cat images were faster and more accurate than the dog images. This finding was found both in the present and previous threat classification task (in Chapter 2). Although the target valence effects did not occur in the RTs, there was evidence for the target valence on the error rates. More errors were found in the responses to the threatening targets than those to the non-threatening targets.

3.3.3 Discussion

Target effects in animal classification task

The target valence effect was found in the animal classification task: participants responded to the threatening targets more slowly than to the non-threatening targets. In Experiment 5 this effect only occurred in the data from the cat trials; and in Experiment 6, the target valence effect generalised to both the cat and dog target trials. This exactly replicated the findings in the animal classification task in Chapter 2. Again, the target valence effect can be explained by the response relevance hypothesis: when threat was task irrelevant, the attention captured by the threatening valence needs to be shifted to other task relevant information. As threatening valence can hold attention longer than non-threatening valence, the disengagement of attention from the target valence was slower in the threatening target cases than in the non-threatening target cases. Therefore, threatening targets were responded to more slowly than the non-threatening targets.

Target effects in threat classification task

There was no target effect in the threat classification task in Experiment 5. However, in Experiment 6, the target effects on the task performance have been enhanced by the inclusion of more stimuli. When comparing the data from no flanker/neutral flanker conditions, the target valence effect was found in the error data. More errors were found in the responses to the threatening targets than to the non-threatening targets. However, the target valence effect did not occur in the RT data. In the emotion/ animal congruency flanker conditions, the cat targets was responded to faster than the dog targets; this is the target animal category effect. This effect was also found in the threat classification task in Chapter 2. One of the

possible reasons was that the cat images carried more salient and homogenous cues (e.g. distinctive stripes) than the dog images and those cues facilitated the responses to targets.

Flanker effects in animal classification task and threat classification task

Fenske and Eastwood (2003) and Horstmann, et al. (2006) found flanker compatibility effects by using positive facial stimuli, but not by using negative facial stimuli. A concern with their studies was that the targets and flankers were identical in the compatible flanker conditions. Consequently, whether the flanker compatibility effects were actually due to the emotion congruency or due to the identical perceptual features of the images was unclear. Zhou and Liu (2013) utilized more facial stimuli in their flanker tasks. They found emotion congruency flanker effects when the emotion was task relevant (in the emotion identification task). Their studies showed that the emotion congruency can influence task performance; no matter whether the emotion was positive or negative.

There was a fast same effect in Experiment 5 with the presence of identical targets and flankers. After ruling out the presence of identical targets and flankers, no flanker effects were found in Experiment 6. Why no emotion congruency effect was found in the previous two experiments was not fully clear. It is possible that there were other influential factors for the flanker compatibility effects; and the next experiment aimed to explore these factors.

3.4. Experiment 7

The questions were can we find evidence for the flanker compatibility effects when the targets and flankers were congruent but different? If yes, any stimuli control can be taken to reveal the flanker compatibility effects. The flanker experiment by Gathercole and Broadbent (1987) provides some useful ideas to possibly important presentation variables. In a flanker experiment by Gathercole and Broadbent (1987), participants responded to the identity of the target letter (A or B) with compatible flanker letters (AAA or BBB) or incompatible letters (BAB or ABA). The distance between flanker images and the targets were either near (< 1 deg)

or far (> 1 deg); and the flankers were presented in three stimulus onset asynchrony (SOA) conditions: - 40 SOA (40 ms before the presence of the target), 0 SOA (simultaneously), and +40 SOA (40 ms after the presence of the target). The findings were that the flanker compatibility effects occurred at the - 40 SOA in both near and far distances; at 0 SOA only when the flankers were near; and no flanker compatibility effects were found at + 40 SOA in either distance conditions. These results suggested that apart from the presence of identical stimuli, two important factors may cause the flanker compatibility effects: 1) the distance between the target and flanker images and 2) the time of arrival of the targets and flankers.

The distance between the targets and flankers and the time of arrival of the targets and flankers were the key factors. In Experiment 6, targets and flankers were presented 4.5° away from each other's centre. To enhance the chance for flanker effects to emerge, the most straightforward idea is to reduce the distance between the targets and the flankers. However, the size of images could not be reduced without making them indistinguishable, hence the distance between the targets and flankers remained as before. In Experiment 7 the time of arrival of the stimuli was manipulated: the flankers were presented prior to the target images.

3.4.1. Method

Participants

Sixteen naïve participants (mean age = 21, 3 male) were recruited from students of York University. There were four left-handed individuals. They received either a course credit or £4. All of the participants reported normal or corrected-to-normal vision.

Stimuli and procedure

The stimuli were the same as those used in Experiment 6. The following events took place on each trial. The trial commenced when a row of three crosses was displayed on the screen for 1,000 ms. Within the next 150 ms the two outer crosses were replaced by the flankers. The centre cross remain flanked until it was replaced by the target image. RTs were measured from the onset of the target image display. A feedback ("correct", "error") was presented after a response for 300 ms.

The performance tasks were the same as Experiment 5 and 6. In total the two tasks lasted approximately 55 mins.

3.4.2 Results

3.4.2.1 Animal classification task

The analysis of the critical flanker conditions

The same method of analysis used in the previous two experiments was used here. The analysis revealed a statistically significant main effect of target valence, $F(1, 15) = 17.7$, $MSE = 9962$, $p = .001$ (mean RTs were 784 ms and 733 ms for threatening target trials and non-threatening target trials, respectively; see Figure 3.8.). Participants classified the threatening targets more slowly than the non-threatening targets. No flanker effects were revealed.

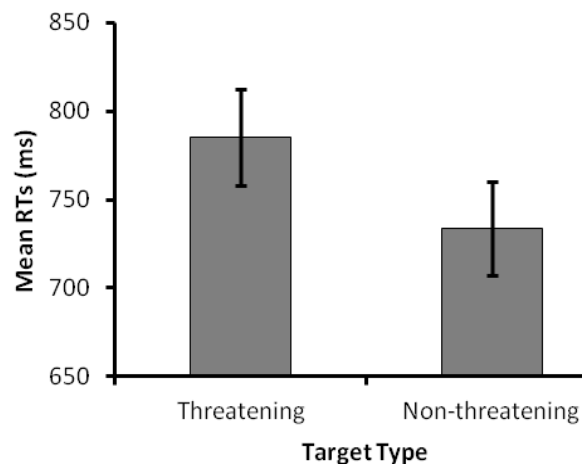


Figure 3.8. Mean reaction times (RTs) for the threatening and non-threatening targets in the animal classification task of Experiment 7.

Analysis of the transformed error scores revealed a statistically significant main effect of target valence, $F(1, 15) = 16.4$, $MSE = 0.06$, $p = .001$. Participants responded more accurately to the non-threatening targets than the threatening targets. There were two two-way interactions: the target valence and target animal interaction, $F(1, 15) = 5.2$, $MSE = 0.07$, $p < .05$; and the target animal and animal congruency interaction, $F(1, 15) = 12.7$, $MSE = 0.01$, $p < .05$. In addition two three-way interactions were also revealed: the target valence x target animal x animal

congruency interaction, $F(1, 15) = 5.1$, $MSE = 0.09$, $p < .05$; and the target valence x emotion congruency x animal congruency interaction, $F(1, 15) = 5.4$, $MSE = 0.02$, $p < .05$.

In order to examine the reliable effects in more details, separate three-way ANOVAs were carried out on the data from the cat and dog target trials, respectively (see Figure 3.9). For the cat trials, a statistically significant main effect was found for target valence, $F(1, 15) = 17.02$, $MSE = 0.07$, $p = .001$; participants responded more accurately to the non-threatening targets than the threatening targets. The animal congruency effect was also found, $F(1, 15) = 6.8$, $MSE = 0.03$, $p < .05$; participants responded more accurately to the targets with animal congruent flankers than with animal incongruent flankers.

For the dog trials, the results revealed a three way interaction of target valence x emotion congruency x animal congruency, $F(1, 15) = 5.0$, $MSE = 0.02$, $p < .05$. No further statistically significant effects were found in the HSD test. There was no evidence of any systematic speed-accuracy trade-offs.

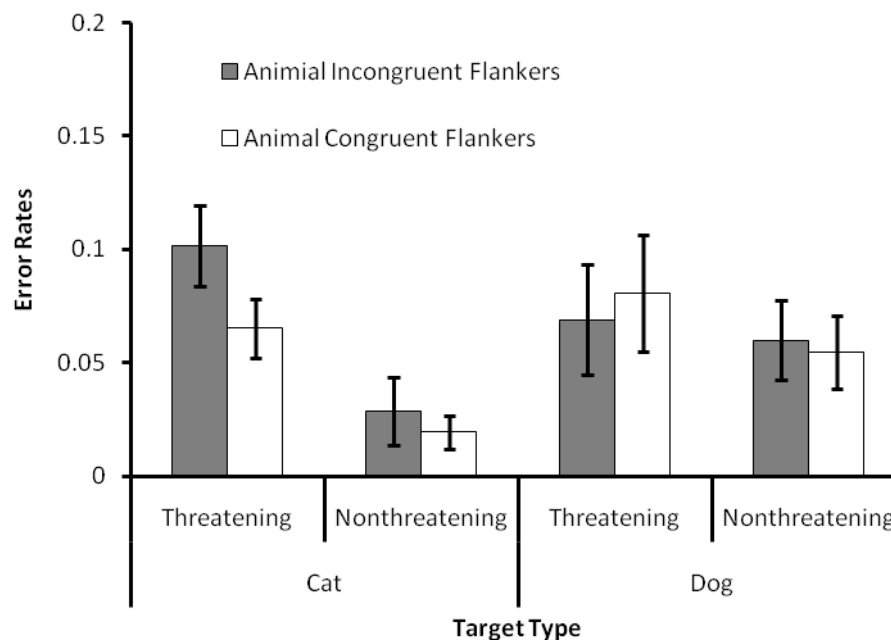


Figure 3.9. Response error rate for the targets in animal incongruent/congruent flanker conditions in the animal classification task of Experiment 7. Error bars reflect within-participant standard errors.

Summary

The findings in the RTs analysis were straightforward: The target valence effect (participants responded to the threatening targets more slowly than to the non-threatening targets) occurred again. The target valence was found to influence error rates as well: more errors were found in responses to the threatening targets than to the non-threatening targets (however, only in the data from cat target trials, but not in the data from dog target trials). There were no flanker effects on RTs, but there was some evidence for the animal congruency flanker effect in the error rates: more errors were found in the animal incongruent flanker conditions than in the animal congruent flanker conditions. However, this animal congruency flanker effect only occurred in the data from the cat target trials, but did not generalise to the dog target trials.

The analysis of neutral flanker/no flanker conditions

The analysis of RTs from the neutral and no-flanker conditions revealed a statistically significant main effect of target valence, $F(1, 15) = 19.4$, $MSE = 4539$, $p < .001$ (mean RTs were 783 ms for threatening target trials and 732ms for non-threatening target trials, respectively); and a reversed flanker presence effect was statistically significant, $F(1, 15) = 5.6$, $MSE = 1892$, $p < .05$ (mean RTs were 748 ms for neutral flanker trials, and 766 ms for no-flanker trials, respectively).

An analysis of transformed error scores found that the main effect of target valence was statistically significant, $F(1, 15) = 11.4$, $MSE = .04$, $p < .01$. Error rates were 7.2% for the threatening target trials and 3.5% for the non-threatening target trials. No flanker effects were revealed. There was no evidence of any systematic speed-accuracy trade-offs in the data.

Summary

The responses to the threatening targets were slower and less accurate than to the non-threatening targets; this is the target valence effect. Responses to targets were faster when targets were presented with neutral flankers than with no flankers;

this is the opposite to the finding in Experiment 5; in which, participants responded to the targets faster when they were alone than with neutral flankers. The reason for this reversed flanker presence effect will be discussed later.

3.4.2.2 Threat classification task

The analysis of the critical flanker conditions

The ANOVA revealed a statistically significant main effect of target animal category, $F(1, 15) = 23.6$, $MSE = 2267$, $p < .001$ (mean RTs were 691 ms and 719 ms for cat target trials and dog target trials, respectively; see Figure 3.10.). Participants classified the cat images faster than the dog images. No flanker effects were found.

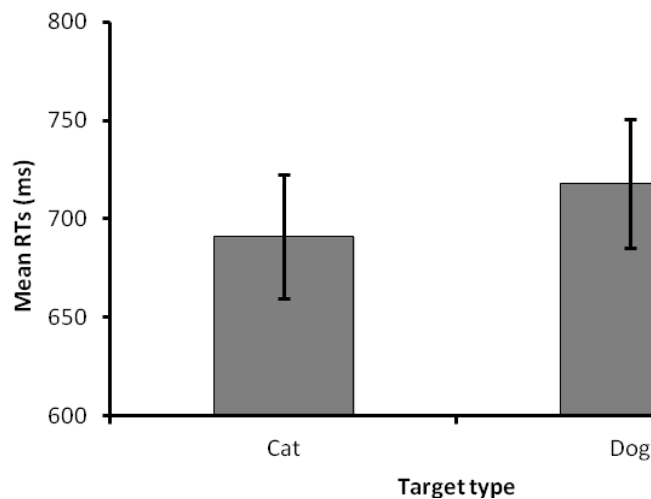


Figure 3.10. Mean reaction times (RTs) for the cat and dog targets in the threat classification task of Experiment 7.

Analysis of the transformed error scores from critical flanker conditions revealed a statistically significant main effect of target animal category, $F(1, 15) = 5.5$, $MSE = 0.08$, $p < .05$. Also, two two-way interactions were statistically significant: the interaction between the target valence and the target animal, $F(1, 15) = 12.1$, $MSE = 0.05$, $p < .05$, and the interaction between emotion congruency and animal congruency, $F(1, 15) = 7.6$, $MSE = 0.03$, $p < .05$. In addition a three-way

interaction, target animal x emotion congruency x animal congruency, $F(1, 15) = 9.7$, $MSE = 0.01$, $p < .05$, was statistically reliable.

In order to examine the reliable effects in more detail, separate three-way ANOVAs were carried out on the data from the cat and dog target trials, respectively. No significant effects were found in the data from the dog trials.

The data from the cat trials revealed a statistically significant main effect of target valence, $F(1, 15) = 5.4$, $MSE = .08$, $p < .05$. Participants responded to the threatening cat targets more accurately than to the non-threatening cat targets, this is the reversed target valence effect. The emotion congruency x animal congruency interaction was also statistically significant, $F(1, 15) = 15.1$, $MSE = 0.02$, $p = .01$. A HSD test revealed that the emotion congruency effect occurred in the animal incongruent flanker conditions (when the cat targets were presented with dog flankers, the error rates were 5.5% and 2.5% for emotion incongruent dog flanker conditions and emotion congruent dog flanker conditions, respectively); and the reversed emotion congruency effect occurred in the animal congruent flanker conditions (when the cat targets were presented with cat flankers, the error rates were 2.7%, and 5.7% for emotion incongruent cat flanker conditions and emotion congruent cat flanker conditions, respectively). There was no evidence of any systematic speed-accuracy trade-offs in the data.

Summary

The target animal category effect was found in the RTs analysis: cat targets were responded to faster than dog targets; this target animal category effect was also found in the threat classification task in Experiment 6 and Chapter 2. A reversed target valence effect was found in the error analysis: participants responded to the threatening targets more accurately than to the non-threatening targets. This reversed target valence effect only occurred in the cat target trials, but not in the dog target trials.

There were no flanker effects in the RT data, but there was some evidence for flanker effects on the error rates in the data from the cat target trials: when the cat targets were presented with cat flankers, more errors were found in the emotion congruent cat flanker conditions than in the emotion incongruent cat flanker conditions. When the cat targets were presented with dog flankers, less errors were

found in the emotion congruent dog flanker conditions than in the emotion incongruent dog flankers. There was no clear reason for this pattern.

The analysis of neutral flanker/no flanker conditions

The ANOVA of RTs from neutral flanker and non-flanker conditions revealed a main effect of target animal category, $F(1, 15) = 9.5$, $MSE = 1617$; $p < .01$ (mean RTs were 703 ms for cat target trials and 725 ms for dog target trials). A reversed flanker presence effect was statistically significant, $F(1, 15) = 10.9$, $MSE = 1088$, $p = .005$ (mean RTs were 705 ms for neutral flanker trials and 723 ms for no-flanker trials).

Analysis of transformed error scores from the neutral and no flanker conditions revealed a statistically significant main target animal category effect, $F(1, 15) = 11.4$, $MSE = .05$, $p < .01$, and a target valence x target animal category interaction, $F(1, 15) = 9.2$, $MSE = .05$, $p < .001$. The HSD test did not reveal further statistically significant effects. There was no evidence of any systematic speed-accuracy trade-offs.

Summary

The cat targets were responded to faster than the dog targets. Faster responses were found when targets were presented with neutral flankers than with no flankers.

3.4.3 Discussion

Target effects in the animal classification task

The target valence effect, participants responded more slowly to the threatening targets than to the non-threatening targets, occurred again. The detailed explanation for this was discussed in Experiments 5 and 6. In brief, when threat was task irrelevant, the attention needs to be disengaged from stimuli valence to task relevant information, as threat holds attention longer than non-threatening targets; threatening stimuli elicit slower responses than non-threatening stimuli.

Target effects in the threat classification task

The target animal category effect was found, responses were faster to the cat targets than to the dog targets; this effect was also found in the threat classification task in Experiment 6. It is possible that the cat images were more homogenous than the dog images and easier to be recognised.

There was a piece of evidence for a reversed target valence effect in the error data: fewer errors were found in the responses to the threatening targets than to the non-threatening targets. This reversed target valence effect only occurred in the cat target trials, but not in the dog target trials; and did not occur in the RT data. This reversed target valence effect was not robust and no convincing conclusion could be drawn from the result.

The flanker effects

Comparing the data from the neutral flanker and no flanker conditions, participants responded to the targets faster when they were presented with neutral flankers than when they were alone. This is the opposite to the finding in Experiment 5, in which participants responded to the targets faster in the no flanker conditions than in the neutral flanker conditions. The explanation could be due to the different experiment designs: In Experiment 5, in each display three images (a target and two flankers) were presented simultaneously in the neutral flanker conditions; and only one image was presented in the no flanker conditions. Therefore, the information load is higher in the neutral flanker conditions than in the no flanker conditions. The higher the load participants needed to process, the more slowly they made responses; therefore, single targets were responded to faster than the targets with flankers. In Experiment 7 the flankers were presented prior to the targets in the neutral flanker conditions; participants were primed by the presence of images and ready to make a response to the targets. When no flankers were presented in advance, no responses were primed and participants responded to the targets more slowly.

Apart from the flanker presence effects, the main interest was how flanker congruency influenced performance. In the emotion/animal congruent/incongruent flanker conditions, no flanker effects were found in the RT data. However, there was some evidence for the flanker effects on the error rates: in the animal classification

task, the animal congruency flanker effects – more errors were found in the animal incongruent flanker conditions than in the animal congruent flanker conditions – were only found in the data from the cat target trials. In the threat classification task, the emotion congruency interacted with animal congruency in the data from the cat target trials: when the cat targets were presented with cat flankers, more errors were found with the emotion congruent cat flankers than with the emotion incongruent cat flankers. When the cat targets were presented with dog flankers, less errors were found with the emotion congruent dog flankers than with the emotion incongruent dog flankers. Overall, there was some evidence for the flanker effects from the error rates data of cat target trials. However, the patterns were not consistent and there were no clear reasons for these results.

3.5. Experiment 8

After ruling out the presence of identical targets and flankers, controlling the time of arrival of the stimuli did not reveal any flanker compatibility effects in the RT data in Experiment 7. On these grounds it is useful to consider other target/flanker manipulations that have been documented in the literature. Miller (1991) claimed that the size of flankers could have an influence on the flanker compatibility effects. In Miller (1991) flanker Experiment 2, a row of three letters was presented in each display; the target letters were presented at 2.4° wide and 0.95° high and the flanker letters were presented at 2.4° wide and 4.8° high (the size of the flanker letters were bigger than the size of the target images). The flanker letters were separated from the targets by about 5° of visual angle. The flanker compatibility effects were only found in the increased flanker cases, suggesting that by varying the size of the flankers, unattended stimuli in the periphery could be processed even when the flankers and targets were located several degrees away. Encouraged by these results the flankers in the following experiment were increased in size because of a similar reason described by Miller. The same tasks used in previous experiments were used in Experiment 8. The stimuli used in Experiments 6 and 7 were also used in Experiment 8.

3.5.1 Method

Participants

Sixteen naive participants (mean age = 24, 5 male) were recruited from students of York University. There were four left-handed individuals. They received either a course credit or £4. All of the participants reported normal or corrected-to-normal vision.

Stimuli and procedure

The stimuli which were used in Experiment 7 were selected for Experiment 8. The target images were kept the same (4.1° wide x 3.2° high). The size of the flanker images were enlarged to 12.5° (wide) x 9° (high) visual angle. The experimental procedure was the same as that of Experiment 3.

3.5.2 Results

3.5.2.1 Animal classification task

The analysis of the critical flanker conditions

Two statistically significant main effects were revealed from the analysis of the RT data: the main effect of target valence effect, $F(1, 15) = 21.316$, $MSE = 10729$, $p < .001$ (mean RTs were 740 ms and 681 ms for threatening target trials and non-threatening target trials, respectively); participants responded to the threatening targets more slowly than to the non-threatening targets. The main effect of the target animal category was also statistically significant, $F(1, 15) = 7.6$, $MSE = 11567$, $P < .05$ (mean RTs were 692 ms and 729 ms for cat targets and dog targets, respectively); participants responded to the cat targets faster than to the dog targets. There were no statistically reliable flanker effects.

The ANOVA of the transformed error scores revealed a statistically significant main effect of target valence, $F(1, 15) = 10.8$, $MSE = 0.086$, $p = .005$. Participants responded more accurately to the non-threatening targets than the threatening targets. The main effect of target animal category was statistically significant, $F(1, 15) = 4.7$, $MSE = .05$, $p < .05$ (the average error rates were 8% and 7% for cat targets and dog targets, respectively); more errors were found in the responses to the cat targets than to the dog targets. Comparing the speed with the

error rates, the data reveals that participants tended to trade accuracy for speed on the cat target trials. Aside from this there was no other evidence of any systematic speed/accuracy trade-offs in the data.

The interaction between the target valence and the emotion congruency reached statistical significance as well, $F(1, 15) = 11.6$, $MSE = 0.02$, $p < .01$. The HSD test showed that participants responded to the non-threatening targets more accurately than the threatening targets, and this effect did not reach statistical significance when the flankers and targets portrayed the same emotional valence (see Figure 3.11.).

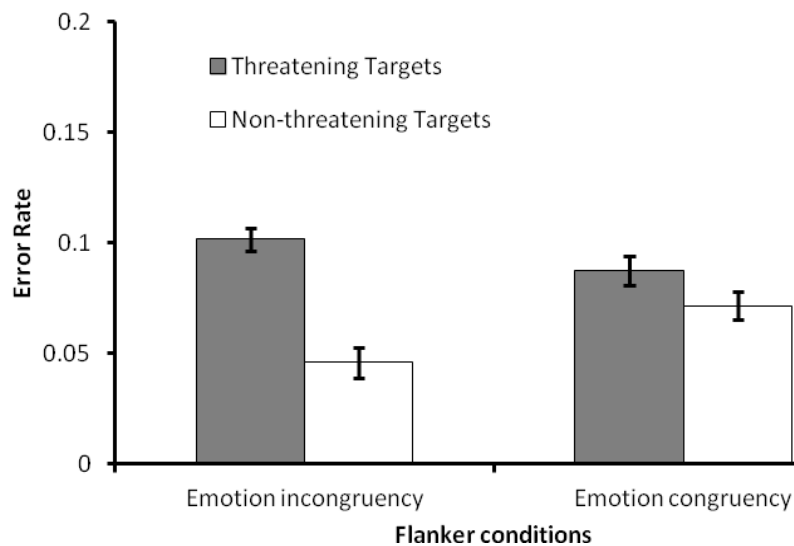


Figure 3.11. Error rates in the animal classification task of Experiment 8. Error bars reflect within-participant standard errors.

Summary

The target valence effect was found again: participants responded to the threatening targets more slowly than to the non-threatening targets; this effect was robustly replicated through Experiments 5 to 8. The target valence effect was also found in the error rates; more errors were found in the responses to the threatening targets than to the non-threatening targets. However, the target valence effect on error rates did not reach statistical significance in the emotion congruent flanker conditions, in which the targets and flankers convey the same valence. The target animal category effect was revealed for the first time in the RT data in the animal classification task: participants responded to the cat targets faster than to the dog targets; this effect was generally found in the threat classification task in previous

experiments. However, combining the findings in the error analysis found more errors in the responses to the cat targets than to the dog targets; there was a clear speed-accuracy trade off. Apart from the target effects, there was no indication of flanker effects.

The analysis of neutral flanker/no flanker conditions

The ANOVA of RTs of neutral and no flanker conditions revealed a statistically significant main effect of target valence, $F(1, 15) = 14.3$, $MSE = 6293$, $p < .05$; participants responded to the threatening targets more slowly than to the non-threatening targets. The reversed flanker presence effect was also statistically significant, $F(1, 15) = 6.7$, $MSE = 2095$, $p < .05$; participants responded to the targets faster when they were with neutral flankers than when presented alone.

The interaction between flanker presence and target animal category also reached statistical significance, $F(1, 15) = 6.4$, $MSE = 2178$, $p < .05$. The HSD test revealed that in the dog target trials there was a reversed flanker presence effect; dog images were responded to faster when they were with neutral flankers (687 ms) than without flankers (729 ms); however, there was no such effect in the data from the cat target trials.

The interaction between the target valence and the target animal category was also statistically significant, $F(1, 15) = 4.7$, $MSE = 7855$, $p = .046$. The HSD test revealed that in the dog target trials, the threatening targets were responded to more slowly than the non-threatening targets; however, this effect did not generalise to the cat target trials (mean RTs were 708ms, 689ms, 751ms and 664ms for threatening cats, non-threatening cats, threatening dogs and non-threatening dogs, respectively).

Analysis of transformed error scores from the neutral flanker and the no-flanker conditions found a statistically significant main effect of target valence, $F(1, 15) = 6.6$, $MSE = .06$, $p < .05$ (the error rates were 5.2% for the non-threatening target trials and 8.6% for the threatening target trials); and the target animal category effect, $F(1, 15) = 8.3$, $MSE = .03$, $p < .05$. More errors were found in the responses to the cat targets (8.1%) than to the dog targets (5.5%). There was no evidence of any systematic speed-accuracy trade-offs in the data.

Summary

The findings in the RTs analysis were that in the data from dog target trials, there was a target valence effect, participants responded to the threatening targets faster than to the non-threatening targets; as well as a reversed flanker presence effect, participants responded to the targets faster when they were with flankers than with no flankers. However, no effects were found in the data from the cat target trials. There were two target effects in the error rates analysis: the target valence effect, more errors were found in responses to the threatening targets than to the non-threatening targets and the reversed target animal category effect, participants made more errors in the responses to the cat targets than to the dog targets.

3.5.2.2 Threat classification task

The analysis of the critical flanker conditions

The ANOVA of RTs revealed only a statistically significant interaction between target animal category and emotion congruency, $F(1, 15) = 4.6$, $MSE = 5138$, $p < .05$. In the dog target trials, participants responded faster to targets in the emotion congruent flanker conditions than in the emotion incongruent flankers, which was an emotion congruency flanker effect; however, this effect did not generalise to the cat target trials (see Figure 3.12).

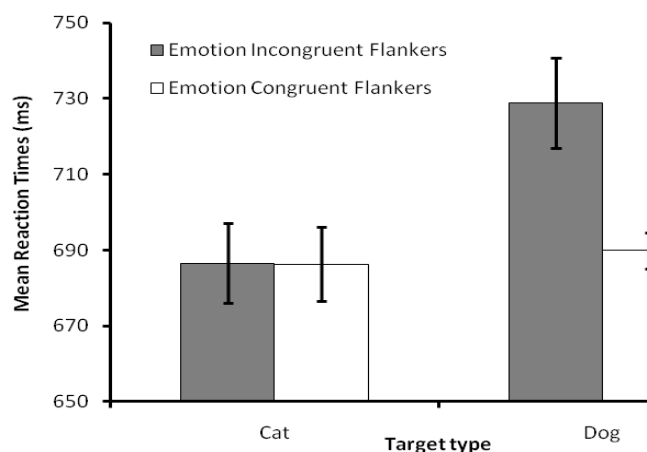


Figure 3.12. Mean reaction times for cat and dog targets in emotion incongruent/congruent flanker conditions in the threat classification task of Experiment 8. Error bars reflect within-participant standard errors.

Analysis of the transformed error scores from the critical flanker conditions revealed a statistically significant main effect of target animal category, $F(1, 15) = 18.01$, $MSE = 0.04$, $p < .001$, participants responded to the cat targets more accurately than to the dog targets (error rates were 5.5% for the cat target trials and 8.8% for the dog target trials). There was also a statistically significant target valence x emotion congruency interaction, $F(1, 15) = 8.4$, $MSE = 0.01$, $p < .05$. There was an emotion congruency flanker effect in the threatening target trials: participants responded more accurately to the threatening targets when the flankers were threatening than when the flankers were non-threatening. However, there were no emotional congruency flanker effects in the non-threatening target trials (see Figure 3.13.). There was no evidence of any systematic speed-accuracy trade-offs in the data.

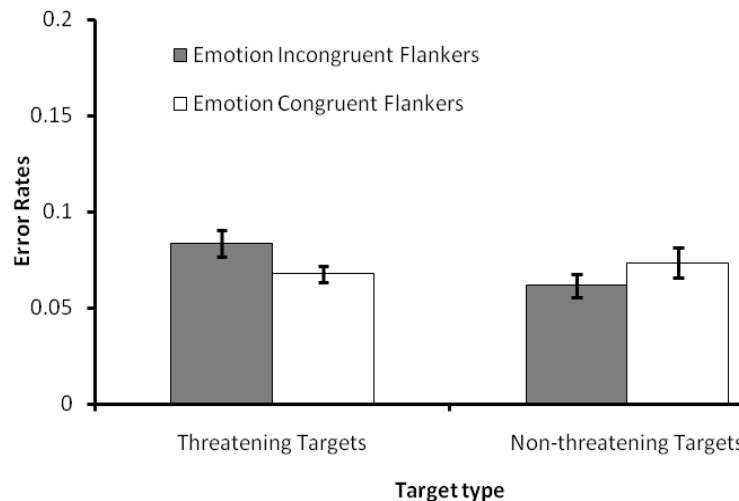


Figure 3.13. Error rates for threatening and non-threatening targets in emotion incongruent/congruent flanker conditions in the threat classification task of Experiment 8. Error bars reflect within-participant standard.

Summary

The analysis of the RT data did not reveal any target effects, however, there was a target animal category effect on the error rates: participants responded to the cat targets more accurately than to the dog targets. There was some evidence for the emotion congruency flanker effect in the RT data: participants responded faster to targets in the emotion congruent flanker conditions than in the emotion incongruent flanker conditions; the emotion congruency effect only occurred in the dog target trials. In the error rates analysis the emotion congruency effect occurred in the threatening target trials, participants responded more accurately to the threatening

targets when the flankers were threatening than when the flankers were non-threatening.

The analysis of neutral flanker/no flanker conditions

The ANOVA of RTs of neutral and no flanker conditions revealed a statistically significant interaction between the target valence and the target animal category, $F(1, 15) = 6.3$, $MSE = 7234$, $p < .05$ (mean RTs were 676 ms, 737 ms, 705 ms and 691 ms for threatening cat targets, threatening dog targets, non-threatening cat targets and non-threatening dog targets, respectively). The HSD test did not reveal any further statistically significant effects.

The analysis of transformed error scores from the neutral flanker and no-flanker conditions found a statistically significant main effect of the target animal category, $F(1, 15) = 9.9$, $MSE = .05$, $p < .05$ (the error rates were 5.7% for the cat target trials and 9.4% for the dog target trials); and the reversed flanker presence effect was also statistically significant, $F(1, 15) = 7.9$, $MSE = .002$, $p < .05$ (mean error rates were 6.4% for the neutral flanker trials, and 8.7% for the no flanker trials). There was no evidence of any systematic speed-accuracy trade-offs in the data.

Summary

There were no clear main effects on the RTs. There was a target animal category effect on the error rates: participants responded to the cat targets more accurately than to the dog targets. Also, participants responded to the targets more accurately with neutral flankers than with no flankers.

3.5.3. Discussion

Target effects in the animal classification task

In the animal classification task target valence effects were found in both the RT and error data: participants responded to the threatening targets more slowly and less accurately than to the non-threatening targets. The target valence effect is consistent with notions of response relevance: threatening targets hold attention

longer than non-threatening targets. When threat was task-irrelevant, attention was disengaged from the threatening targets more slowly than from the non-threatening targets; therefore responses to threats were slower than those to non-threats.

Target effects in the threat classification task

The target animal category effect was found in the error analysis: participants responded to the cat targets more accurately than to the dog targets. One possibility is that the cat images carried more homogenous visual cues (e.g., distinctive stripes) than dog images, and these cues facilitated the responses to the cat targets.

Flanker effects

In the study by Zhou and Liu (2013) the emotion congruency effect was found in both happy and fearful face conditions in an emotion judgement task. In the current experiment, there was some evidence for the emotion congruency flanker effect on RT data: in the threat classification task participants responded faster to targets in the emotion congruent flanker conditions than in the emotion incongruent flanker conditions. However, this effect only occurred in the dog target trials, but did not generalise to the cat target trials. Possibly emotion processing is more complex when using non-facial emotional stimuli. Besides the task relevance, there may be other factors influencing the occurrence of the emotion congruency effect, for instance, the processing of categorical information.

Another finding was that in the error analysis the emotion congruency effect occurred in the threatening target trials, participants responded more accurately to the threatening targets when the flankers were threatening than when the flankers were non-threatening. This result suggests that the threatening flankers may facilitate responses to the targets under certain conditions. For instance, when the targets were threatening the stimuli valence was task relevant (e.g., in the threat classification). More questions arise, for instance, can we find more evidence for the threatening flankers facilitate the responses to the target threat? What is the relationship between the processing of flanker valence and the processing of the target valence? Are task requirements relevant to the occurrence of the effects? The next experiment aimed to explore these questions.

3.6. Experiment 9

Lichtenstein-Vidne, Henik, and Safadi (2011) may provide some useful points to explore the relationship between flanker valence and target valence. They designed a different version of the flanker experiment, in which the stimulus display consisted of a 3 x 3 grid (see Figure 3.14.). The targets were non-emotional pictures (their Experiment 1) or emotional pictures (positive, negative; their Experiment 2) and appeared randomly above or below a central fixation cross. The flankers (positive, neutral or negative pictures) were always presented simultaneously in the peripheral columns above, below or at the level of fixation. In both of the experiments participants were required to judge the up/down location of a central target, which was located either above or below the fixation.

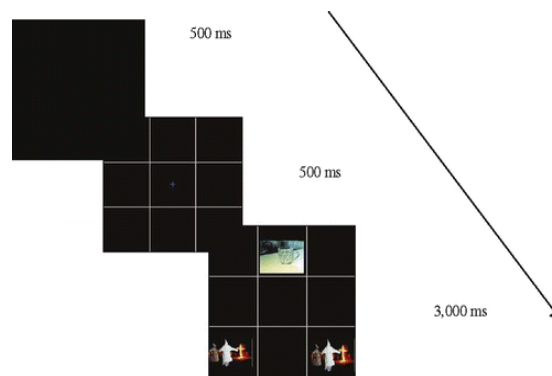


Figure 3.14. An example of a typical trial presented in flanker experiments of Lichtenstein-Vidne, Henik and Safadi (2011).

In their experiment three effects were of interest: (i) the *location congruency effect*, (ii) the *flanker valence effect* and (iii) the *target valence effect*. The location congruency effect occurs when responses to the target are quicker when both target and flankers are located at the same vertical position than when they are not. This effect was found in both their Experiment 1 and Experiment 2. The flanker valence effect occurred when response speed was modulated by the emotional content of the flankers. Such an effect was found in their Experiment 2: participants responded more slowly to the emotional targets in the presence of negative flankers than to targets in the presence of neutral and positive flankers. In addition, RTs to the latter two cases did not differ. Finally, a target valence effect occurred when the emotional

content of the target modulates response speed. Again, such an effect was only found only in their Experiment 2, as emotional pictures were selected as stimuli.

According to the findings in Lichtenstein-Vidne, et al. (2011), the threatening flankers could influence performance with the presence of threatening targets; and the negative valence impaired the performance in a non-valence judgement task. To test these predictions the following experiments replicated the design of Lichtenstein-Vidne, et al. (2011) with the same stimuli used in Experiments 6-8. In Experiment 9a only threatening stimuli were selected as the target images and in Experiment 9b only non-threatening (neutral) stimuli were presented as the targets. The flanker valence effect was expected in Experiment 9a, but not in Experiment 9b.

3.6.1. Experiment 9a

3.6.1.1. Method

Stimuli and procedure

The same stimuli sets selected for Experiments 6-8 were used in Experiment 9. The central area of the screen consisted of 3 x 3 squares (three columns of three equal squares). Each testing trial was composed of a threatening target picture presented in the central column and two identical flanking emotional pictures were presented in the left and right columns. The valence of the flanker pictures (threatening or non-threatening) changed randomly from trial to trial. Each picture was presented in 4° x 4° in one small square. The stimuli varied from trial to trial and were randomly selected from the image sets.

The target appeared randomly above or below a central fixation cross (i.e., inside the focus of attention). The flankers could appear above, below or at the level of fixation. The location of the flanker was congruent (e.g., target and flankers above fixation), neutral (e.g., target above fixation with flankers located next to fixation) or incongruent (e.g., target above fixation with flankers located below fixation) with the target's location.

A typical trial started with a black screen for 150 ms. Next, a fixation cross appeared in the central square for another 150 ms. Afterwards, a single target with two identical flankers appeared concurrently. The participants sat approximately 57 cm from the screen were required to judge whether the location of the target picture was above or below a central fixation cross by pressing keys: the 'right' key for up

and the 'left' key for down. The target and flankers remained in view until the participant's key press, but not for more than 3,000 ms. Participants were asked to respond as quickly and as accurately as possible. The inter-trial interval was 1,500 ms, measured from the participant's response onset. The experiment began with 10 practice trials in the presence of the experimenter, followed by the actual experimental trials that included four experimental blocks, each one containing 192 trials.

Participants

Sixteen naive participants (mean age = 24, 5 male, 4 left-handed) were recruited for Experiment 9a. They received either a course credit or £2. All of the participants reported normal or corrected-to-normal vision.

3.6.1.2. Results

The mean RTs were analysed with a 2 (target animal: cat vs. dog) x 3 (location congruency: congruent, neutral, and incongruent) x 2 (flanker valence: threatening vs. nonthreatening) x 2 (flanker animal: cat vs. dog) repeated measures ANOVA. The main effect of location congruency was statistically significant, $F(2, 30) = 14.1$, $MSE = 1430$, $p < .001$ (mean RTs were 416 ms, 416 ms and 438 ms for congruent, neutral and incongruent locations, respectively).

There were two statistically significant interactions: target animal x flanker valence, $F(1, 15) = 6.9$, $MSE = 386.9$, $P < .05$; and target animal category x flanker animal category, $F(1, 15) = 6.6$, $MSE = 597.7$, $P < .05$. A HSD test for the interaction of target animal category and flanker valence revealed that in the presence of non-threatening flankers, participants responded to threatening cats more slowly than to threatening dogs (mean RTs were 426 ms and 419 ms, respectively), this was the reversed target animal category effect and this effect did not occur in the threatening flanker conditions. In addition, the flanker valence effect was only found in the threatening dog target trials: participants responded to the threatening dogs with threatening flankers more slowly than those with the non-threatening flankers (mean RTs were 425 ms and 419 ms, respectively).

The interaction between target animal category and flanker animal category was also analysed by HSD test (see Figure 3.15.). The animal congruency flanker effect was revealed in the threatening cat trials; participants responded to the threatening cat targets more slowly with the dog flanker than those with the cat flankers (mean RTs were 428 ms and 420 ms, respectively). Participants tended to respond to the threatening dogs faster with the dog flankers (419 ms) than with the cat flankers (425 ms); however, the difference in RTs did not reach statistical significance.

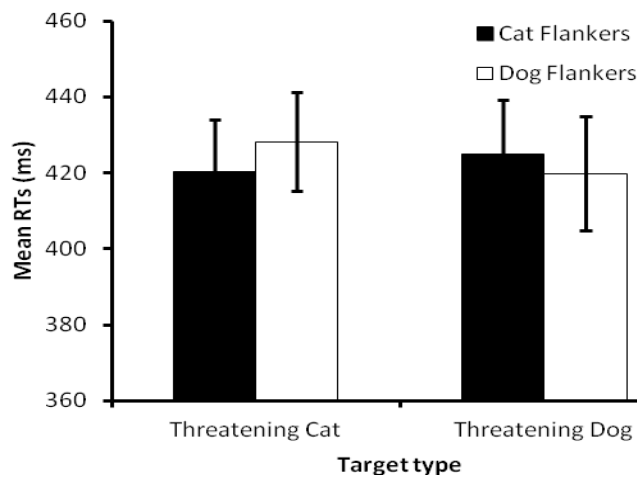


Figure 3.15. Mean reaction times (RTs) for threatening cat and threatening dog targets in cat/dog flanker conditions. Error bars reflect within-participant standard errors.

The ANOVA of the transformed error scores revealed a statistically significant interaction between flanker valence and flanker animal category, $F(1, 15) = 6.2$, $MSE = .005$, $p < .05$. This interaction was further analysed by HSD test and the results showed that participants responded less accurately in the non-threatening dog flanker conditions than in the other three flanker conditions (non-threatening cat flankers, threatening dog flankers and threatening cat flankers). The mean error rates were 4.1%, 2.9%, 2.9% and 3.4% for non-threatening dog flanker trials, non-threatening cat flanker trials, threatening dog trials and threatening cat trials, respectively. There was no evidence of any systematic speed-accuracy trade-offs in the data.

Summary

Overall, using the threatening stimuli as the targets and both threatening and non-threatening stimuli as flankers, the findings in Experiment 9a were: 1) the flanker location congruency effect was replicated, participants responded to the targets faster when the target and the flankers were presented in the same row (either above or below central fixation) than when they were in different rows. 2) There was a reversed target animal category effect in the non-threatening flanker conditions, participants responded to threatening cats more slowly than threatening dogs. 3) The flanker valence effect was only found in the threatening dog target trials; participants responded to threatening dogs more slowly when they were with threatening flankers than they were with non-threatening flankers. 4) The animal congruency flanker effect was found in the threatening cat target trials; participants responded to the targets faster when the targets and flankers were all cat images than when the flankers were dog images. This effect did not generalise to the threatening dog target trials. 5) Participants responded less accurately in the non-threatening dog flanker conditions than in the other three flanker conditions (threatening dog, non-threatening cat and threatening cat flanker trials); there was no obvious reason for this.

3.6.2. Experiment 9b

3.6.2.1. Method

Stimuli and procedure

The procedure was the same as used in Experiment 9a. The threatening target images used in Experiment 9a were replaced by non-threatening target images, which were the same as the ones used in Experiments 6-8. The flanker images were the same as in Experiment 9a.

Participants

Another sixteen naive participants (mean age = 23, 2 male, 1 left-handed) were recruited from students of York University. They received either a course credit or £2. All of the participants reported normal or corrected-to-normal vision.

3.6.2.2. Results

The ANOVA of the RTs revealed a statistically significant main effect of location congruency, $F(2, 30) = 10.3$, $MSE = 1294$, $p < .001$ (mean RTs were 412 ms, 406 ms and 425 ms for congruent, neutral and incongruent positions, respectively).

An ANOVA of the transformed error scores revealed a statistically significant main effect of location congruency, $F(2, 30) = 5.2$, $MSE = 0.12$, $p < .05$. Participants responded more accurately when the targets and flankers were presented in the same row (error rates were 1.7%, 2.2%, and 3.2% for congruent, neutral and incongruent trials, respectively). There was no evidence of any systematic speed-accuracy trade-offs.

Summary

The location congruency effect was replicated again, participants responded to the targets faster when the target and flankers were presented in the same row (either above or below central fixation) than when they were in different rows. There were no other target or flanker effects.

3.6.3. Across tasks comparisons

The RTs from both Experiment 9a and Experiment 9b were tested together to explore if the threatening targets generally slowed down the responses comparing non-threatening targets. The same ANOVA as in Experiment 9a was used. In addition, the valence of the targets was included as the between-subjects factor. The mean RT analysis and the error analysis did not find a significant difference between the two groups, $F(1, 30) < 1$, (the mean RTs were 423 ms and 414 ms for the threatening targets trials and the non-threatening trials, respectively).

3.6.4. Discussion

There were no target effects found in Experiment 9. The flankers influenced the judgement of the target location, participants responded to the targets faster when the target and the flankers were presented in the same row (either above or below

central fixation) than when they were in different rows. These location congruency effects were well replicated in Experiments 9a and 9b, regardless of the target valence (threatening, non-threatening). The location of flankers did influence the processing of the target locations.

The main interest in this experiment was to explore the relationship between the processing of the target valence and the processing of the flanker valence. Lichtenstein-Vidne, et al. (2011) found the flanker valence effect, in which threatening flankers slowed down the responses to threatening targets. Furthermore, there was no flanker valence effect when the targets were non-threatening. Presently, the flanker valence effect occurred in the threatening dog target trials, but not in the threatening cat target trials. There was no robust evidence for the flanker valence effect in the current experiment.

3.7. General Discussion

For a summary of the results of Experiments 5-9 see Table 3.3. The general discussion is divided into three sections, starting with the target effects, followed by the flanker effects and then moves on to the conclusion.

Table 3.3.

A summary table of the effects on Reaction Times (RTs) and Error rates (Ers) in Experiments 5-9.

Tasks	Target effects				Flanker effects			
	Valence effect		Animal category effect		Animal congruency effect		Emotion congruency effect	
	RTs	Ers	RTs	Ers	RTs	Ers	RTs	Ers
Animal classification								
Exp5	√ (C)	X	X	X	√	X	√	X
Exp6	√	√	X	X	X	√ (D)	X	X
Exp7	√	√ (C)	X	X	X	√ (C)	X	X
Exp8	√	√	√	X	X	X	X	X
Threat classification								
Exp5	X	X	X	X	X	X	X	X
Exp6	X	X	√	X	X	X	X	X
Exp7	X	X	√	√	X	X	X	X
Exp8	X	X	X	√	X	X	√ (D)	√ (T)
Location judgement								
	Flanker effect							
	Location congruency effect				Animal congruency effect		Valence effect	
	RTs	Ers			RTs	Ers	RTs	Ers
Experiment 9a	√	X			√(TC)	X	√(TD)	X
Experiment 9b	√	X			X	X	X	X

Note: √ - the effect was found. X - no effect was found. (C)- the effect only found in cat trials. (D)- the effect only found in dog trials. (T)- the effect only found in threatening trials. (TC)- the effect only found in threatening cat trials. (TD)- the effect only found in the threatening dog trials. ‘The target valence effect’- threat slowed down performance. ‘The target animal category effect’- the cat targets were responded to faster than the dog targets. ‘The animal congruency flanker effect’- participants responded to the targets faster when the targets and flankers were from the same animal category than when the targets and flankers were from different animal category. ‘The emotion congruency flanker effect’- participants responded to the targets faster when the targets and flankers have the same valence (e.g., the target and flankers were all threatening images) than they have different valence (e.g. the target was threatening and the flankers were non-threatening).

The target effects

In the animal classification task, the target valence effects robustly occurred throughout Experiments 5-8 – participants responded to the threatening images more slowly than to the non-threatening images. The response relevant hypothesis can be used to explain why threat slowed down performance: threatening targets can hold attention longer than non-threatening targets. When the target threats are task irrelevant, attention needs to be disengaged from stimuli valence and be directed towards the task relevant features (e.g. animal category in the animal classification

task). Therefore, responses to threatening targets were evoked more slowly than to non-threatening targets.

However, the response hypothesis could not explain why there was no evidence for the influence of valence when threat was task relevant (in the threat classification task). According to the response relevance hypothesis, threat holds attention longer than neutral valence. In the threat classification task, as threat was task-relevant, attention was not required to disengage from the target valence. Therefore, threatening targets were predicted to be responded to relatively faster than non-threatening targets, this is the reversed target valence effect. However, there were no such effects in the current experiments.

In contrast, there were reversed target valence effects in the threat classification tasks in Chapter 2: participants responded to the threatening targets faster than to the non-threatening targets. Comparing these experiments, apart from the task requirements, there could be other factors influencing the valence processing. For instance, the difference of experimental designs could be the main reason for the null results in the current case. In the previous chapter only one image, to which participants were required to respond, was presented in the centre of the screen in each display. In the present experiment one central target was presented with flankers on each side in a display. The information load was different in these two paradigms: low load in the single item paradigms and high load in the flanker paradigms. The reversed target valence effects only occurred in the single item paradigms, which were the low load conditions, possibly indicating the effects can only occur in the low load conditions and that high load impaired the reversed target valence effect.

In this chapter the target animal category effects were found consistently in the threat classification task - participants responded to the cat targets faster than to the dog targets. Images of domestic cats were selected for the non-threatening cat images; and images of tigers, lions and leopards were selected for the threatening cat images. Compared with the cat images, the dog images were selected from a wider range of sub-categories. Furthermore, the perceptual cues, such as colour and shape, carried by the dog images vary more than those in the cat images. One possible reason for the target animal category effects was that the cat images were more

homogenous than the dog images, therefore cat images were easier to be recognised. However, if the homogeneously perceptual cues can facilitate responses, why this effect only occurred in threat classification task, but not in the animal classification task? There was no clear answer for this question so far. The current results indicated that the process of categorical information and task requirements are complex.

The flanker effects

There was a fast same effect in Experiment 5 and this effect was due to the presence of the identical targets and flankers. This result lead to the question as to whether there would be flanker compatibility effects after ruling out presenting the identical images in the flanker experiments and Experiments 6-8 were designed to explore this. There were several strategies of flanker manipulations: to enlarge the stimuli set size (Experiment 6), to present the flankers prior to the targets (Experiment 7) and to enlarge the flanker size, as well as to present the flankers prior to the targets (Experiment 8). Although there was a piece of evidence found in Experiment 8, that by enlarging the flanker size there was an emotion congruency effect in the dog target trials, the general findings were that there were no robust flanker compatibility effects in Experiments 6-8. So far, the occurrence of flanker compatibility effects was well explored by manipulating stimuli factors in different ways and there was no reliable flanker compatibility effect across experiments.

In the location judgement task in Experiment 9, the location congruency effect, participants responded to the targets faster when the target and the flankers were presented in the same row (either above or below central fixation) than when they were in different rows, was well replicated as in Lichtenstein-Vidne, et al. (2011), indicating the spatial location of the flankers can facilitate the processing of the target locations. Another flanker effect was the flanker valence effect in the threatening dog trials, participants responded to threatening dogs more slowly when they were with threatening flankers than when they were with non-threatening flankers. This flanker valence effect did not occur in other types of target trials. Therefore, the flanker valence effect was not reliable in Experiment 9. Collectively, the flanker effects in this chapter can be well explained by perceptual factors, and no convincing evidence showed that parafoveal threat influences performance.

Conclusion

In conclusion, flanker paradigms were employed in this chapter. Participants were required to do animal classification, threat classification and location judgement tasks. Across these tasks two target effects were revealed consistently: the target valence effects in the animal classification tasks (the target threat slowed down performance) and the target animal category effects in the threat classification tasks (cat targets were responded to faster than dog targets). Apart from the target effects, there was a fast same effect in the animal classification task in Experiment 5 and an emotion congruency effect (only in the dog target trials) in the threat classification task in Experiment 8. In the location judgement task in Experiment 9, the threatening flankers were found to slow down performance to the threatening dog targets. Although the flankers were found to influence the task performance in some cases, there were no consistent flanker compatibility effects in this chapter. The findings in this chapter will be discussed in more detail in Chapter 5.

Chapter 4 Threat processing in visual search tasks

4.1. Introduction

The main interest in this chapter is to explore how humans detect visual threat when it is presented in a random position in the peripheral visual field. One of the most influential theories was developed by Öhman and his colleagues (Öhman, 1999; Öhman & Mineka, 2001): to enhance the chance of surviving in environment, humans have evolved a *fear system* (Öhman & Mineka, 2001), which is specially elicited by fear and fear learning. According to the *Fear response hypothesis*, the fear system produces an automatic early warning signal, and alerts the observer to the threat. As a consequence, the fear system should be invoked quickly and automatically when threat confronts an observer.

According to the fear response hypothesis, threat is detected rapidly and automatically. Many studies have been done to test this *threat detection advantage*; and the most common paradigm that has been used is the *speeded visual search task*. Since the inception of visual feature integration theory (Treisman & Gelade, 1980), many variants of speeded visual search have been developed. In the standard search task, it is possible to define a search display as containing a number of to-be-searched items (the search items). Display set size (henceforth, *display size*) is defined according to the number of search items contained in a display. Typically, participants are given one or more pre-defined targets that might occur within a search display and they are required to judge; in each trial, whether a target is present or absent. Across trials, the display size is varied. Both measures of speed and accuracy are taken and these are mapped out as a function of the content of the search display and the size of the search display.

In the pioneering work by Öhman, Flykt and Esteves (2001), an oddball version of the search task was employed to examine the threat detection advantage, the mean reaction times (RTs) were shorter in detecting the oddball item (henceforth, the target) when it was threatening than when it was non-threatening. Full colour photographic images of plants or animals were selected to be the search items. Participants were required to judge whether all the search items were taken from the same biological category or whether there was a distinctive singleton (an oddball) present. Spiders and snakes were used as fear-relevant (threatening) items, and

flowers and mushrooms were used as fear-irrelevant (non-threatening) items. In their Experiment 1, when the display size was fixed at nine items, the threat detection advantage was found. In their Experiment 2, when the display size was varied (either four or nine items across trials), the threat advantage still occurred. Moreover, it was found that, statistically, RTs to detect the threatening target were the same regardless of how many items were to be searched. However, RTs did increase directly as a function of display size when the target was a non-threatening item.

Besides the RTs, search slope, the numerical increase in RTs with display size, is also an important measurement. In studies by Öhman, et al. (2001), in the threatening target trials, the search slope was 3 ms/item, which fell within “the limits of a maximum of the 5-6 ms/item that has been required for parallel searches in the literature (e.g., Treisman & Souther, 1985)” (p. 471). This very shallow slope suggested that threat detecting was automatic. Overall, the basic finding reported by Öhman et al. (2001), was of a threat advantage such that the responses to displays containing a threatening image were relatively fast and less affected by increases in display size than were response to displays containing a non-threatening image.

Following the ground breaking work by Öhman et al. (2001), there has been some further work on the influence of threat in speeded visual search tasks (Blanchette, 2006; Brosch & Sharma, 2005; Lipp, Derakshan, Waters & Logies, 2004). However, there were some concerns about stimuli confounds. For example, Tipples, Young, Quinlan, Broks and Ellis (2002) replicated the threat advantage in the searching for threatening animals among non-threatening plants, as well as, for the non-threatening animals among non-threatening plants. Collectively, the data were taken to suggest that the original threat advantage (found by both Öhman et al., 2001, Experiment 2, and Tipples et al., 2002, Experiment 1) was confounded with the animal/plant distinction and that the actual target advantage was due to better detection of animals than of plants, regardless of the emotional valence of the images.

LoBue and DeLoache (2008) considered the influence of animal distinctiveness, and took some careful steps to avoid confounding variables. In their first experiment, images of snakes and flowers were used as search items such that search for a distinctive snake amongst flowers was compared with search for a distinctive flower amongst snakes. The original threat/animal advantage was found.

In their second experiment, however, LoBue and DeLoache (2008) examined performance with images of snakes and frogs. Search for a distinctive snake amongst frogs was compared with search for a distinctive frog amongst snakes. The results of this experiment revealed a strong snake advantage, such that the detection of a snake target was easier than the detection of a frog target. This difference was interpreted as being a real threat advantage because both targets were animals embedded in displays containing images of other animals. Hence the detection of a distinctive animal was not in itself sufficient to explain why images of snakes were easier to respond to than images of frogs. In a final experiment, they went further and tested search for a target snake compared with search for a target caterpillar. Arguably this experiment provided controls for both animal detection (as snakes and caterpillars are both animals) and distinctive shape detection (because snakes and caterpillars are of a similar shape). Under these conditions, although a threat advantage was present in the data collected from young children, there was no such advantage in the data collected from adults. For children, snake targets were detected faster than the caterpillar targets, but for adults there was no difference in detection speed across these two target types. LoBue and DeLoache (2008) raised the fact that the very distinctive, elongated, limbless shape of a snake might contribute to their rapid detection.

Therefore, there is mixed evidence for threat advantage. Previous studies highlight some of the problems and pitfalls that may arise when attempting to study speeded detection of threat. For instance, the basic target/non-target categorical differences should be controlled for, as the difference in particular colours or spatial frequencies could influence the responses (see Cave & Batty, 2006).

Another concern about the original experiments (e.g., Öhman et al., 2001, Experiment 1), is that the targets were both distinctive in being the only animal image in the display and also in being the only threatening image in the display. Questions could be asked as to what degree the snake advantage is due to speed of detection, speed of identification or both. It is possible to ask about the degree to which the threat advantage is due to speeded detection (is a particular kind of target present?) versus target identification (what kind of target is present?). Such a question is particularly pertinent, given the fear response hypothesis claims that the

fear response can be invoked even though the nature of the actual threat has yet to be identified.

Bearing these concerns in mind, (1) to establish firm evidence for a threat advantage, more careful experimental controls had been introduced, and (2) to provide direct support for a basic claim of the fear response hypothesis that threat items can be readily detected prior to being fully identified; the current experiments were carried out in speeded visual search tasks by comparing target detection with target classification.

In exploring such issues comparisons were made between target detection and target classification in two speeded visual search tasks based on the oddball task described by Öhman et al. (2001). (1) In the *detection task*, participants merely had to judge whether an image of a distinctive target animal was present on each trial. Each of the search items was a photograph that contained the image of a single animal. On a random half of the trials no target image was present. Participants were simply instructed to press one key if the search display contained images of only birds and to press a different key if a distinctive image of an animal (in this case, a dog or cat) other than a bird was present. (2) In contrast, in the *classification task* on every trial a target image was present and participants had to classify what kind of animal the target was. They simply had to press one key if the target image was of a dog and a different key if the target image was of a cat. In both cases the non-target images were of well-known wild birds (not birds of prey). Half the target images were of dogs and half were of cats; and for both of these categories, half of the images depicted threatening animals and half depicted non-threatening animals. In neither of these tasks was the emotional valence of the target image a cue to response, hence any effects of emotional valence – in this case, threat – cannot be due to some form of response priming.

4.2. Experiment 10

According to the fear response hypothesis, the basic prediction is that detection responses should be faster on threatening target trials (on trials where the target is an image of a threatening animal) than on non-threatening target trials (on trials where the target is an image of a non-threatening animal). This is despite the

fact that the valence of the target images is incidental to the response. Of additional interest is the degree to which effects are mirrored in the data for the classification task.

In the classification task, participants were instructed to classify the target as either a dog or cat and, again, the emotional valence of the images (threatening vs. non-threatening) had no bearing on this decision. Nonetheless, on the grounds that threatening images are easier to detect than non-threatening images, it would seem plausible that any benefits that might accrue during search are preserved at the level of target classification. At the very least, therefore, it could be argued that the same effects of threat found in the detection data ought to be present in the data for the classification task. Any differential effects of threat across the two tasks would then suggest that the influence of threat varies according to the task constraints.

4.2.1. Method

Stimuli

Each photograph (i.e., each search item) depicted a single animal in its natural habitat rendered in full colour. Each photograph was 5.5° (wide) x 3.5° (high) visual angle. Photographs were arrayed around a virtual circle whose radius was 8.5°. When nine photographs were presented, the photographs were spaced at the apexes of a nine-sided polygon. These nine screen positions acted for the photographic places holders for all of the displays. For the smaller display sizes, the item positions were chosen at random from these nine placeholders prior to each trial. Each of the four target sets of photographs (threatening/non-threatening cats and dogs) comprising 48 different items were the same stimuli used in Chapters 2-3. The non-target items for a given display were selected at random (without replacement) prior to each trial from a basic set of 421 bird images.

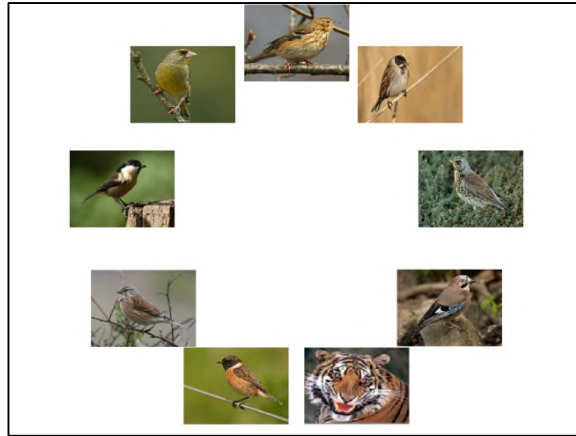


Figure 4.1. An example of the kind of displays used in Experiment 10.

Design

In the detection task, the experimental trials were divided into four blocks. Within each block there were 96 trials in total, 48 trials contained a target (henceforth were Present trials) and 48 contained no target (henceforth were Absent trials). Within the Present trials there were 16 trials for each display size and, for each display size, there were four items chosen from each of the four target sets. Corresponding Absent trials were configured. Each participant saw each target only once in the detection task and the allocation of targets to the particular display sizes was randomised across participants. There were 384 experimental trials in total and the ordering of the trials within the blocks was randomised for each participant. Prior to the experimental trials there was a single block of 24 practice trials and the targets in these practice trials were different from the targets in the experimental trials.

In the classification task, each display contained a target and the structure of the blocks was the same as in the detection task but without the Absent trials. The participants' task was to classify the target as depicting either a dog or a cat. There were 48 trials per block and half contained a photograph of a dog and half a photograph of a cat. Half of the targets were threatening images and half were non-threatening images. Within each block, there were 16 trials for each display size and for each display size there were four items chosen from each of the four target sets. The balancing and allocation of the items to the displays was as before. In this case, there were 192 experimental trials and a single block of 12 practice trials was

administered prior to the experimental trials. No target item was presented more than once in the classification task and the same target items were used as in the detection task.

Half of the participants carried out the detection task prior to the classification task and for the remaining participants this order was reversed. In the detection task, half of the participants responded 'Present' with a left key press and half responded 'Present' with a right key press. In the classification tasks task half of the participants responded 'DOG' with a left key press and half responded 'DOG' with a right key press.

Apparatus

The E-prime program (Schneider, Eschman, & Zuccolotto, 2002), running on a Windows 2000 PC, was used for controlling the experiments. In addition, an E-prime response box was used to collect the responses. Keys 1 and 2 were used throughout. Stimulus delivery was via a 15" SONY monitor (model CPD-100ES). Auditory trial feedback when an error was committed (i.e., a standard beep) was delivered via headphones.

Participants

Twenty-four naive participants (mean age = 22, 18 female) were recruited from students of York University. There were two left-handed individuals. They received either a course credit or £4. All of the participants reported normal or corrected-to-normal vision.

Procedure

Each participant was tested individually in a quiet, window-less, testing cubicle. Participants sat at a table in front of a chin rest situated 57 cm from a computer screen which was located on a raised plinth. The centre of the screen was at eye-level. On the table in front of the screen was placed the E-prime button box. The screen and response box were linked to a PC computer situated outside the cubicle.

Initially, participants were provided with task instructions and the response allocation was described. They were also told that response timing began once the search display was presented and that they had to respond as quickly and as accurately as possible.

Participants initiated a block of trials with any response key press. Every trial began with the presentation of a central fixation mark (i.e., a “+”) for 600 ms. At the offset of the fixation plus, the search display was immediately presented. The display remained on until the computer detected a key press response. Whenever an error was committed the computer issued a beep. The inter-trial interval was set at 1 s.

In total the detection tasks lasted approximately 25 mins and the classification task lasted 15 mins. Both tasks were completed in a single testing session with the detection task being administered first.

4.2.2. Results

The main interest is the mean correct RTs and percentage error rates. Such measures were computed for each participant for each condition of interest. When the errors were analysed, they were first converted into proportions and then arcsin transformed following the advice of Keppel and Wickens (2004).

4.2.2.1 Detection task

Figure 4.2. shows the search functions from the trials for the four target types together with that for the Absent trials. Initially, interest is in the data for the Present trials.

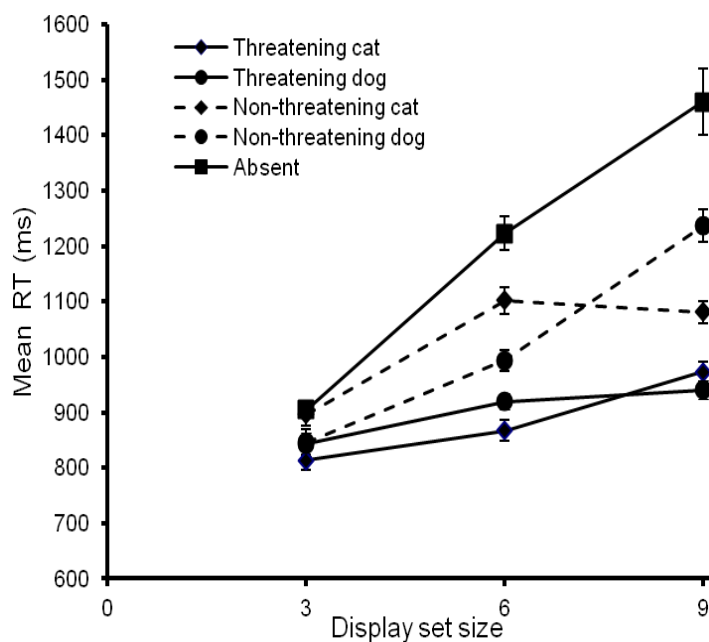


Figure 4.2. Mean reaction times (RTs) in the detection task, Experiment10. Error bars reflect within-participant standard errors.

Present trials

RTs.

The mean correct RTs were entered into a 2 x 2 x 3 repeated-measures ANOVA in which emotional valence (threatening vs. non-threatening), animal (cat vs. dog) and display set size (3, 6, 9 items) were entered as fixed factors and 'participant' was entered as a random factor. The analysis revealed statistically significant main effects of valence, $F(1, 23) = 81.3$, $MSE = 15729$, $p < .001$, and display set size, $F(2, 46) = 81.7$, $MSE = 12808$, $p < .001$; $F < 1.0$, for the main effect of animal.

Two-way interactions between valence and display set size, $F(2, 46) = 24.5$, $MSE = 6573$, $p < .001$, and between animal and display set size, $F(2, 46) = 8.6$, $MSE = 6324$, $p = .001$, were also statistically reliable. Finally the three-way interaction between valence, animal and display set size also reached statistical significance, $F(2, 46) = 22.3$, $MSE = 8924$, $p < .001$.

In order to examine the reliable three-way interaction in more detail, separate two-way ANOVAs were carried out on the data from the cat and dog target trials, respectively. In both analyses, all three effects were statically reliable. For the data from the cat target trials, $F(1, 23) = 141.0$, $MSE = 5155$, $p < .001$, for the main effect of valence; $F(2, 46) = 44.3$, $MSE = 8646$, $p < .001$, for the main effect of display set size; $F(2, 46) = 8.9$, $MSE = 9098$, $p = .001$, for the valence x display set size interaction. For the data from the dog target trials, the statistically significant effects were, $F(1, 23) = 27.6$, $MSE = 20213$, $p < .001$, for the main effect of valence; $F(2, 46) = 68.4$, $MSE = 10485$, $p < .001$, for the main effect of display set size; and $F(2, 46) = 43.6$, $MSE = 6400$, $p < .001$, for the valence x display set size interaction.

More revealing, perhaps, are the trend analyses of the various search functions. The search functions showed that all four target types gave rise to statistically reliable linear fits. However, significant departures from linearity were found for the threatening dog target trials, $F(1, 23) = 5.4$, $MSE = 2221$, $p < .05$, quadratic component; and for the non-threatening cat target trials, $F(1, 23) = 14.8$, $MSE = 13879$, $p = .001$, quadratic component.

In summary, RTs did tend to increase monotonically with increases in display set size. However, on Present trials these effects were modulated by the valence of the target image. Effects of display set size were much more marked for the non-threatening targets than for the threatening targets. Moreover, the effects were expressed differently according to the category of the target. For both the dog target and cat target trials, the effects of target valence tended to increase as the display set size increased. However, this pattern was least apparent in the data for the cat target trials: responses to the non-threatening targets were relatively short at the largest display set size.

Error rates

Generally speaking error rates were relatively low for these kinds of difficult search tasks (i.e., no condition mean exceeded 14%). Nonetheless, the transformed error scores were analysed in the same way as the RTs. The analysis revealed a statistically significant main effect of valence, $F(1, 23) = 21.2$, $MSE = 0.101$, $p < .001$. In addition, both the valence x display set size interaction, $F(2, 46) = 3.75$, $MSE = 0.045$, $p < .05$, and the animal x display set size interaction, $F(2, 46) = 4.81$, $MSE = 0.046$, $p < .05$, were statistically reliable. Participants missed fewer threatening targets than non-threatening targets and the effects of display set size were less pronounced for threatening targets than non-threatening targets. Finally, the effects of display set size were less marked in the cat than the dog target trials. When considered alongside the RTs, there is no evidence of any systematic speed/accuracy trade-offs in the data.

Absent trials.

The Absent search function was well described by a linear trend, the departure from linearity was statistically reliable, $F(1, 23) = 39.6$, $MSE = 6712$, $p < .001$, quadratic component. This trend is clear from visual inspection of Figure 4.1.

Participants rarely committed errors (no score exceeded 2%) and when analysed in a one-way repeated measures ANOVA, in which display set size acted as fixed factor and participants acted as a random factor, the main effect of display set size failed to reach statistical significance, $F(2, 48) = 2.3$, $MSE = 0.004$, $p > .05$.

4.2.2.2. Classification task

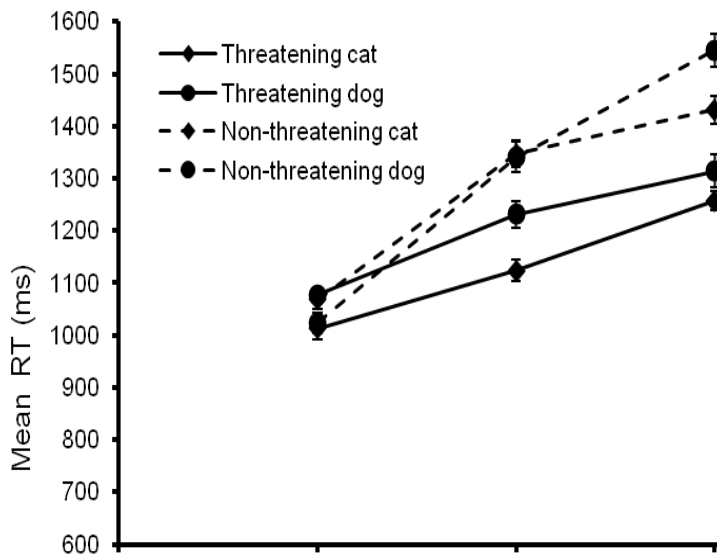


Figure 4.3. Mean Reaction times (RTs) in the classification task, Experiment10. Error bars reflect within-participant standard errors.

RTs.

Figure 4.3 shows the search functions from the trials for the four target types. The mean correct RTs were entered into the same kind of 2 x 2 x 3 repeated-measures ANOVA as used with the Present scores in the detection task. The analysis revealed statistically significant main effects of valence, $F(1, 23) = 50.3$, $MSE = 21707$, $p < .001$; animal, $F(1, 23) = 11.3$, $MSE = 15261$, $p < .01$; and, display set size, $F(2, 46) = 121.1$, $MSE = 23525$, $p < .001$. The two-way interactions between valence and animal, $F(1, 23) = 4.3$, $MSE = 13203$, $p < .05$, between valence and display set size, $F(2, 46) = 20.9$, $MSE = 13153$, $p < .001$, and between animal and display set size, $F(2, 46) = 3.2$, $MSE = 10236$, $p < .05$, were also statistically reliable. Finally, the three way interaction between valence, animal and display set size also reached statistical significance, $F(2, 46) = 5.6$, $MSE = 10137$, $p < .01$.

To examine the results further, separate two-way ANOVAs were carried out for the cat and the dog target trials. As with the detection scores, all three effects were statically reliable in the data for both target types. For the data from the cat trials, $F(1, 23) = 60.7$, $MSE = 13588$, $p < .001$, for the main effect of valence; $F(2, 46) = 102.3$, $MSE = 11082$, $p < .001$, for the main effect of display set size; $F(2, 46) = 7.3$, $MSE = 12041$, $p < .01$, for the valence x display set size interaction. For the

data from the dog target trials, the statistically significant effects were $F(1, 23) = 15.2$, $MSE = 21322$, $p = .001$, for the main effect of valence; $F(2, 46) = 77.1$, $MSE = 22679$, $p < .001$, for the main effect of display set size; $F(2, 46) = 21.7$, $MSE = 11249$, $p < .001$, for the valence x display set size interaction.

Trend analyses of the various search functions revealed that the search functions for the four target types were well described by linear fits. However, a statistically significant departure from linearity was found for the non-threatening cat targets, $F(1,23) = 7.8$, $MSE = 11589$, $p = .01$. Inspection of Figure 4.2 reveals that RTs to the largest display set size were relatively short on the non-threatening cat target trials.

In summary, the effects of display set size were more marked on the non-threatening target trials than on the threatening target trials and this accords with the data from the detection task. Indeed the two data sets are similar in other respects. The interaction between display set size and valence was different in the data for the cat and dog target trials and this difference was similar to that found in the detection experiment. Notably, participants found it relatively easy to classify the non-threatening cats at the largest display set size.

Error rates

As with the detection task, error rates were generally low with no condition mean exceeding 14%. Nonetheless, the transformed error scores were analysed in the same way as the RTs. The analysis revealed a statistically significant main effect of valence, $F(1, 23) = 17.41$, $MSE = 0.046$, $p < .001$. In addition, both the valence x animal interaction, $F(1, 23) = 4.67$, $MSE = 0.056$, $p < .05$, and the valence x display set size interaction, $F(2, 46) = 9.85$, $MSE = 0.021$, $p < .001$, were statistically reliable.

The valence x animal interaction arose because, although participants tended to misclassify the threatening targets more than the non-threatening targets, this difference was particularly marked on the cat target trials. In addition, the valence x display set size interaction arose because, whereas error rates decreased with increases with display set size for the threatening targets, the reverse effect was found for the non-threatening targets.

Both of these two-way interactions are in the main attributable to the relatively high error rate for the threatening cat trials at display size 3. There is no obvious reason for this effect and, aside from this finding, there is no evidence of any systematic speed/accuracy trade-offs in the data.

Across task comparisons

In order to make cross task comparisons, the data for the two target types were analysed further using separate 2 x 2 x 3 repeated measures ANOVAs. In these cases, the valence, display set size and participant factors were as before. Now task (detection vs. classification) was added as the new fixed factor. Analysis of the data from the dog target trials revealed that all three main effects were statistically reliable, $F(1, 23) = 163.9$, $MSE = 37457$, $p < .001$, for the main effect of task; $F(1, 23) = 38.1$, $MSE = 22729$, $p < .001$, for the main effect of valence; and, $F(2, 46) = 134.5$, $MSE = 17357$, $p < .001$, for the main effect of display set size.

Both the task x display set size interaction, $F(2, 46) = 8.4$, $MSE = 15808$, $p = .001$, and the valence x display set size interaction, $F(2, 46) = 73.2$, $MSE = 6912$, $p < .001$, were statistically reliable. Notably, though, the task x valence interaction failed to reach statistical significance, $F < 1.0$; the task x valence x display set size interaction was also not statistically significant, $F(2, 46) = 1.7$, $MSE = 10737$, $p > .05$.

An identical pattern of significance was found in the data from the cat target trials; $F(1, 23) = 195.8$, $MSE = 23181$, $p < .001$, for the main effect of task; $F(1, 23) = 186.6$, $MSE = 8305$, $p < .001$, for the main effect of valence; $F(2, 46) = 140.9$, $MSE = 10023$, $p < .001$, for the main effect of display set size; $F(2, 46) = 10.7$, $MSE = 9706$, $p < .001$, for the task x display set size; $F(2, 46) = 14.4$, $MSE = 10722$, $p < .001$, for the valence x display set size interaction; $F < 1.0$, for the task x valence interaction; and the task x valence x display set size interaction was also not statistically significant, $F(2, 46) = 1.4$, $MSE = 10416$, $p > .05$.

In summary, RTs were shorter in detection task than those in classification task. The difference between RTs from two tasks increased with the increased display set size.

4.2.3. Discussion

The most basic effect is the presence of a threat advantage: responses to displays containing a threatening image were faster than they were to displays containing non-threatening images. As Figure 4.1 shows the effects of valence scaled broadly with display set size but at a level of finer detail the effects were expressed differently for the dog and the cat target trials. The main difference across the two types of targets is that participants were relatively speeded in responding on the non-threatening cat trials at the largest display set size relative to performance with the non-threatening dog trials. Upon reflection, there is no obvious reason for this finding.

Of particular interest is that a threat advantage was also present in the data for the classification task. Indeed comparing across Figure 4.1 and 4.2 the search functions for the different targets are surprisingly comparable. Again the effect of threat tended to scale with display set size and again participants were relatively fast in responding when a non-threatening cat was present at the largest display set size.

In sum, the data provide robust evidence of a threat advantage that does generalise over the stimulus materials – the effects are present in the data for the cat and the dog target trials. This is consistent with the fear response hypothesis. Furthermore, the evidence also shows that the effects of threat found in the detection task are mirrored in the data for the classification task. On these grounds, it seems that the effects of threat shown in the classification task reflect the time taken to find the target image. When across task comparisons were made in the separate analyses of the data from the dog and the cat target trials, in neither case was the task \times valence interaction statistically reliable. Clearly it would be folly to attempt to argue too strongly on the basis of what are essentially null effects. Nonetheless, it is difficult to try to argue that the absence of the reliable interactions is down to a lack of statistical power given the other statistically reliable effects in the data (see Frick, 1995). Therefore, a preliminary conclusion is that the threat advantage reflects speed of detection not classification and this is consistent with the view that the fear system is invoked prior to the nature of the threat being identified.

The generality of the effects was examined in the next experiment in which the format of the images was changed. To address further concerns about possible

stimulus confounds across the target sets of images an obvious next step was to examine the role of colour (see Cave & Batty, 2006). Perhaps, in Experiment 10, the threatening images contained distinctive colours and it was this that was responsible for the basic threat advantage. In order to address this possibility, the experiment was repeated but now the images were rendered into greyscale.

4.3. Experiment 11

4.3.1. Method

In all critical regards the experiment was an exact replication of Experiment 10. The critical differences were that a new participant sample was tested and that the photographic materials were rendered into greyscale. The original full colour images were rendered into greyscale using the B&W effect in the Picasa 3 package distributed by Google. Image statistics are shown in Table 25 (in the appendix), and, as is clear, the transformation into greyscale introduced only very marginal differences in the luminance and contrast values across the two image formats.

Participants

Twenty-eight naive participants (mean age = 20, 23 female) were recruited from students of York University. There were three left-handed individuals. They received either a course credit or £4. All of the participants reported normal or corrected-to-normal vision.

4.3.2. Results

4.3.2.1. Detection task

The same methods of data analysis used in Experiment 10 were used here. Figure 4.4 shows the search functions from the trials for the four target types together with the function for the Absent trials. Initially, interest is with the data for the Present trials.

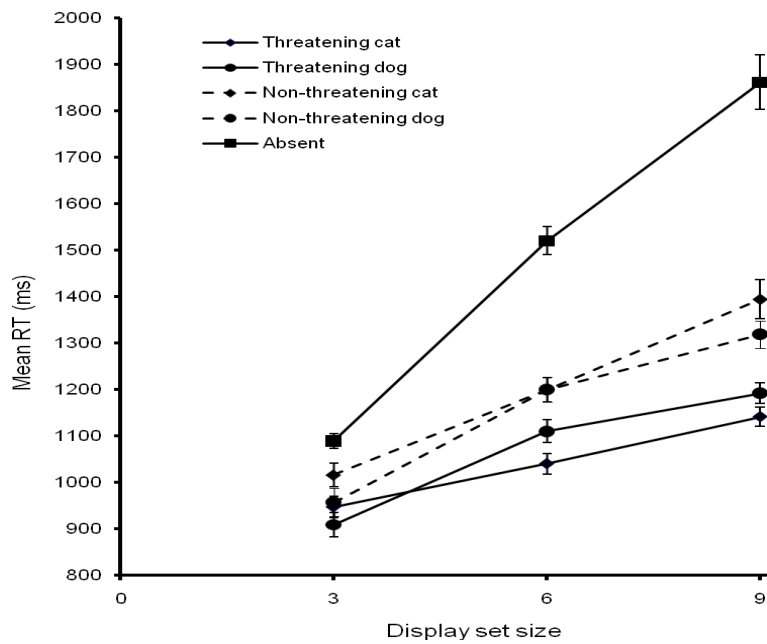


Figure 4.4. Mean reaction times (RTs) in the detection task, Experiment 11. Error bars reflect within-participant standard errors.

Present trials

RTs.

The analysis revealed statistically significant main effects of valence, $F(1, 27) = 54.4$, $MSE = 23866$, $p < .001$, and display set size, $F(2, 54) = 82.9$, $MSE = 31595$, $p < .001$. The two-way interactions between valence and animal, $F(1, 27) = 4.6$, $MSE = 23385$, $p < .05$; valence and display set size, $F(2, 54) = 7.6$, $MSE = 16051$, $p = .001$; and between animal and display set size, $F(2, 54) = 3.5$, $MSE = 13767$, $p < .05$, were all statistically reliable, but the three-way interaction between valence, animal and display set size failed to reach statistical significance, $F < 1.0$.

The valence x display set size shows that the effects of display set size were less marked for the threatening targets than the non-threatening targets (see Figure 4.3.). The animal x display set size interaction was analysed further via the polynomial trend components. It was found that whereas the search function for the cat target trials was well described by a linear component, $F(1, 27) = 112.0$, $MSE = 20503$, $p < .001$, slope = 47.8, $r^2 = 0.99$, there was an indication of a statistically significant departure from linearity for the search function for the dog target trials, $F(1, 27) = 4.2$, $MSE = 32361$, $p = .05$.

The valence x animal interaction was further analysed using a Tukey's HSD test ($\alpha = .05$). Overall, the interaction revealed that the size of the valence effect was greater on the cat target trials than the dog target trials (i.e., the valence effect was 160 ms in the cat target trials and it was 89 ms on the dog target trials). The HSD test revealed, however, that the valence effect was statistically reliable in the data for both kinds of animal targets. The respective mean RTs were 1043 ms, 1203 ms, 1070 ms and 1159 ms, for the threatening cat target trials, the non-threatening cat target trials, the threatening dog target trials and the non-threatening dog target trials.

Error rates

Generally speaking, error rates in this experiment were slightly more pronounced than in Experiment 1 - the maximum score was 16.4% across all cells in the design. Analysis of the transformed error scores revealed statistically significant main effects of valence, $F(1, 27) = 25.2$, $MSE = 0.076$, $p < .001$, and display set size, $F(2, 54) = 9.0$, $MSE = 0.056$, $p < .001$ – no other tests were statistically reliable. The main effect of valence revealed that participants were more accurate in detecting threatening than non-threatening targets. The main effect of display set size showed that accuracy decreased monotonically as display set size increased. When considered alongside the RTs, there is no evidence of any systematic speed/accuracy trade-offs in the data.

Absent trials.

Analysis of the RTs revealed that, although the Absent search function was well fit by a linear trend, the departure from linearity was statistically reliable, $F(1, 27) = 11.7$, $MSE = 3118$, $p < .01$, quadratic component. Participants rarely committed false alarms (no score exceeded 3%). Analysis of the transformed data revealed that the main effect of display set size did not reach statistical reliability, $F(2, 54) = 1.3$, $MSE = 0.006$, $p > .05$.

4.3.2.2. Classification task

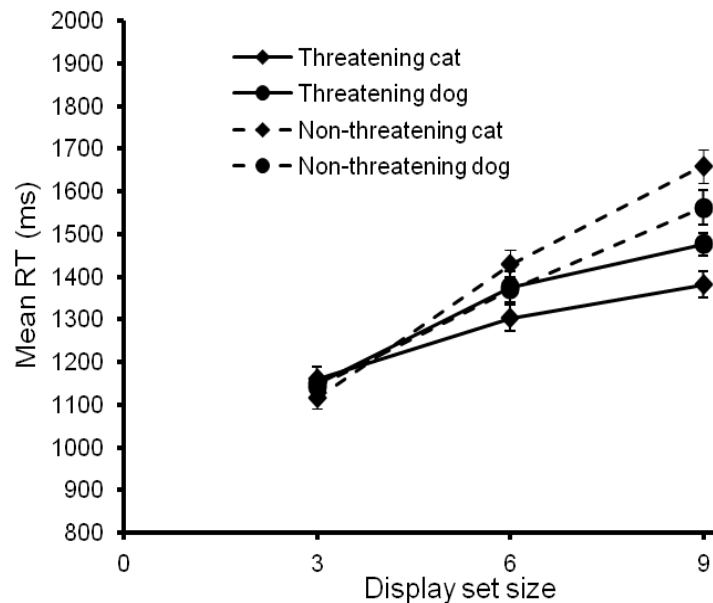


Figure 4.5. Mean reaction times (RTs) in the classification task, Experiment 11. Error bars reflect within-participant standard errors.

RTs.

Figure 4.5 shows the search functions from the trials for the four target types. Analysis revealed statistically significant main effects of valence, $F(1, 27) = 12.7$, $MSE = 34456$, $p = .001$, and display set size, $F(2, 54) = 105.6$, $MSE = 38444$, $p < .001$; $F < 1.0$ for the main effect of animal. Two-way interactions between valence and animal, $F(1, 27) = 8.3$, $MSE = 23319$, $p < .01$, and between valence and display set size, $F(2, 54) = 11.2$, $MSE = 27059$, $p < .001$, were statistically reliable. The interaction between animal and display set size failed to reach statistical significance, $F < 1.0$. Finally, the three way interaction between valence, animal and display set size was also marginally significant, $F(2, 54) = 3.2$, $MSE = 31242$, $p = .05$.

To examine the results further, separate two-way ANOVAs were carried out for the cat and the dog target trials, respectively. For the data from the cat target trials, two main effects and one interaction reached statistical significance, $F(1, 27) = 15.5$, $MSE = 39224$, $p = .001$, for the main effect of valence; $F(2, 54) = 56.1$, $MSE = 36931$, $p < .001$, for the main effect of display set size; $F(2, 54) = 15.9$, $MSE = 22841$, $p < .001$, for the valence x display set size interaction. Trend analyses

revealed that both search functions were well described by linear fits, $F(1, 27) = 30.3$, $MSE = 22637$, $p < .001$, for the threatening targets; $F(1, 27) = 107.4$, $MSE = 38448$, $p < .001$, for the non-threatening targets. The effect of display set size was much more marked for the non-threatening cat targets than the threatening cat targets.

For the data from the dog target trials, the analysis revealed that only the main effect of display set size reached statistical significance, $F(2, 54) = 69.8$, $MSE = 28468$, $p < .001$; $F(1, 27) = 1.3$, $MSE = 18552$, $p > .05$, for the main effect of valence; and, $F(2, 54) = 1.1$, $MSE = 35461$, $p > .05$, for the valence x display set size interaction. The search functions for both threatening and non-threatening targets were well described by linear fits, $F(1, 27) = 99.6$, $MSE = 15120$, $p < .001$, for the threatening targets; $F(1, 27) = 61.4$, $MSE = 40213$, $p < .001$, for the non-threatening targets. Critically there were no effects of valence in the data for the dog target trials.

Error rates

Error rates were not noticeably higher than those reported in Experiment 1 (i.e., no condition mean exceeding 11%). Nonetheless, the transformed error scores were analysed in the same way as the RTs. The analysis revealed a statistically significant main effect of valence, $F(1, 27) = 4.3$, $MSE = 0.067$, $p < .05$, and display set size, $F(2, 54) = 3.4$, $MSE = 0.018$, $p < .05$. In addition, there was a statistically reliable valence x animal interaction, $F(1, 27) = 8.6$, $MSE = 0.03$, $p < .01$. The interaction revealed that whereas the valence effect was present in the data for the cat target trials there was no such effect in the data for the dog target trials. Participants tended to make more errors to threatening cat targets than non-threatening cat targets. Comparing the speed with the accuracy scores, the data reveals that participants tended to trade accuracy for speed on threatening cat target trials. Aside from this there was no other evidence of any systematic speed/accuracy trade-offs in the data.

Across task comparisons.

Across task comparisons were carried out in the same way as in Experiment 10. Analysis of the data from the dog target trials revealed that all three main effects were statistically reliable, $F(1, 27) = 57.3$, $MSE = 78727$, $p < .001$, for the main effect of task; $F(1, 27) = 18.5$, $MSE = 14366$, $p < .001$, for the main effect of valence;

and, $F(2, 54) = 103.3$, $MSE = 33714$, $p < .001$, for the main effect of display set size. Apart from the task x valence interaction, $F(1, 27) = 5.2$, $MSE = 16745$, $p < .05$, no further tests reached statistical significance; $F(2, 54) = 1.6$, $MSE = 35264$, $p > .05$, for the valence x display set size interaction; $F < 1.0$ for both the task x display set size, and the task x valence x display set size interactions.

An HSD test was carried out in order to explore the reasons for the task x valence interaction. It was found that whereas there was no effect of valence in the data for the identification task, $p > .05$, there was such an effect in the data for the detection task, $p < .05$. The mean RTs were 1070 ms, 1159 ms, 1334 ms and 1358 ms, respectively, for the threatening targets in the detection task, the non-threatening targets in the detection task, the threatening targets in the classification task and the non-threatening targets in the classification task, respectively.

A different pattern of effects was present in the data for the cat target trials. As with the data for the dog target trials, all of the main effects reached statistical significance; $F(1, 27) = 37.9$, $MSE = 105995$, $p < .001$, for the main effect of task; $F(1, 27) = 43.9$, $MSE = 37645$, $p < .001$, for the main effect of valence; $F(2, 54) = 99.0$, $MSE = 31710$, $p < .001$, for the main effect of display set size. However, both the task x display set size interaction, $F(2, 54) = 4.1$, $MSE = 19839$, $p < .05$, and the valence x display set size interaction, $F(2, 54) = 21.6$, $MSE = 20710$, $p < .001$, were statistically reliable; $F(1, 27) = 0.92$, $MSE = 36271$, $p > .05$, for the task x valence interaction; and, $F(2, 54) = 1.3$, $MSE = 25151$, $p > .05$, for the task x valence x display set size.

4.3.3. Discussion

The data are both similar to and different from those reported in Experiment 10. First the pattern of effects in the detection task was similar to that found in Experiment 10. The threat advantage was again present in the data for both the cat and dog target trials but, in this case, the effect was larger in the data for the cat target trials than in the data for the dog target trials. The reverse effect was found in Experiment 10. Clearly, the change in image format has influenced performance, but,

critically, the basic threat advantage was still present in the data for the dog and cat target trials.

For the dog target trials, although there was a threat advantage in the data for the dog target trials in the detection task, there was no such effect in the data for the classification task. The threat advantage was present in the data for both tasks for the cat target trials. The most interesting aspect of the data may be the patterns shown in the classification task. The threat advantage may vary across target types and task requirements.

4.4. Experiment 12

The main concern in Experiment 12 is that the degree to which the threat advantage is truly due to the threatening nature of the images used or to some other unknown confounding factor. Perhaps it is just simply easier to categorise the threatening images than the non-threatening images? To address this issue the next experiment was designed to examine basic classification performance when each target image was presented in isolation.

In this case, on every trial, participants were presented with a display containing a single photographic image. This target image was located in the periphery at one of the item positions defined in the original search tasks and the position of the target was randomly determined prior to each trial. Each image was taken from the set of targets used previously and participants were instructed to classify the depicted animal as either a cat or a dog as quickly and as accurately as possible.

Although it is true that the participants may need to locate the target before responding to it, there is no sense in which participants have to discount other potential targets before making a response. Therefore, the assumption is that performance in this single item classification task does not reflect, in any fundamental way, processes of target search. More critically, if the threat advantage in the previous classification tasks was merely due to the threatening images being

easier to classify than the non-threatening images, then this would undermine the previous claims about the potency of threat cues in the search tasks.

4.4.1. Method

Stimuli, Design and Procedure

Two versions of this classification task (animal classification, threat classification) were configured and the versions differed according to whether the images were full colour or greyscale. Participants were tested on both full colour and greyscale conditions and the order of conditions was balanced over individuals. Each condition was tested in 2 blocks of 96 trials. The order of presentation of the total 192 images was randomised and divided into two blocks such that no target within a condition was presented more than once. Prior to the blocks of experimental trials, 12 practice trials were administered. The images in the practice trials were different from those on the experimental trials. Each participant received the images in a different random order.

Participants were tested individually as before. Each trial began with the presentation of a central fixation point for 600 ms. This was then replaced by a single photographic image positioned in the periphery. The target's position was determined prior to the trial, at random from one of the nine image positions used previously in the other search tasks in Experiments 10 and 11. Participants were instructed to respond as quickly and as accurately as possible on each trial.

Participants

Twenty-four naive participants (mean age = 21, 18 female) were recruited from students of York University. There was a single left-handed individual. All of the participants reported normal or corrected-to-normal vision and they received either a course credit or £4.

4.4.2. Results

Prior to analysis of the RTs, responses greater than 3 s were removed as outliers. One response was removed from the animal classification data set and 13 were removed from the threat classification data. The summary data for the correct RTs are shown in Figure 4.6.

Separate analyses were carried out on the data for the two different classification tasks. The data were analysed via a 2 x 2 x 2 repeated measures ANOVA in which the colour (full colour vs. greyscale), valence (threatening vs. non-threatening) and animal (cats vs. dogs.) were entered as fixed factors.

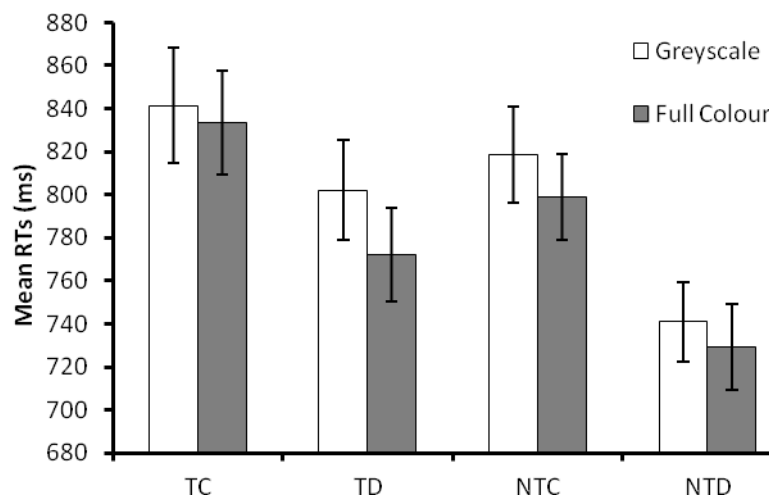


Figure 4.6. Mean reaction times (RTs) in the animal classification task, Experiment 12 (TC-threatening cats; TD-threatening dogs; NTC-Non-threatening cats; NTD-Non-threatening dogs). Error bars reflect within-participant standard errors.

4.4.2.1. Animal classification task

In the analysis of the RTs for the animal classification task, only the main effects of valence, $F(1, 23) = 29.2, p < .001$, and animal, $F(1, 179) = 38.4, p < .001$, were statistically reliable. The main effect of image colour failed to reach statistical significance. No other tests reached statistical significance. As Figure 4.5 shows, participants were slower to classify the threatening images than they were to classify the non-threatening images. Mean RTs were 812 ms and 772 ms, respectively for the

threatening and the non-threatening images. The analysis also revealed that responses were faster overall to the dog (761ms) than the cat images (823 ms).

Error rates were generally low with no cell mean exceeding 7%. The transformed scores were analysed in a 2 x 2 x 2 repeated measures ANOVA in which the same fixed factors were used as before. This analysis revealed that the main effects of valence, $F(1, 23) = 79.5$, $MSE = 0.021$, $p < .001$, and animal, $F(1, 23) = 25.6$, $MSE = 0.039$, $p < .001$, reached statistical reliability. The interaction between valence and animal, $F(1, 23) = 11.9$, $MSE = 0.042$, $p < .001$, also reached statistical reliability. The interaction between valence and animal was due to participants being relatively inaccurate when presented with images of threatening cats. Overall, there was no evidence for any speed/accuracy trade-offs in the data.

4.4.2.2. Threat classification task

The summary data for the correct RTs are shown in Figure 4.7. The ANOVA revealed that the main effects of valence, $F(1, 23) = 11.4$, $MSE = 10355$, $p < .05$ (the mean RTs were 765 and 715ms for the threatening and non-threatening images, respectively). Participants were slower to classify the threatening images than they were to classify the non-threatening images.

The interaction between valence and animal, $F(1, 23) = 12.9$, $MSE = 1001$, $p < .05$, also reached statistical reliability. The HSD test revealed that the threatening cats were responded to faster than the threatening dogs; however this animal effect did not reach statistical significance in the non-threatening target cases.

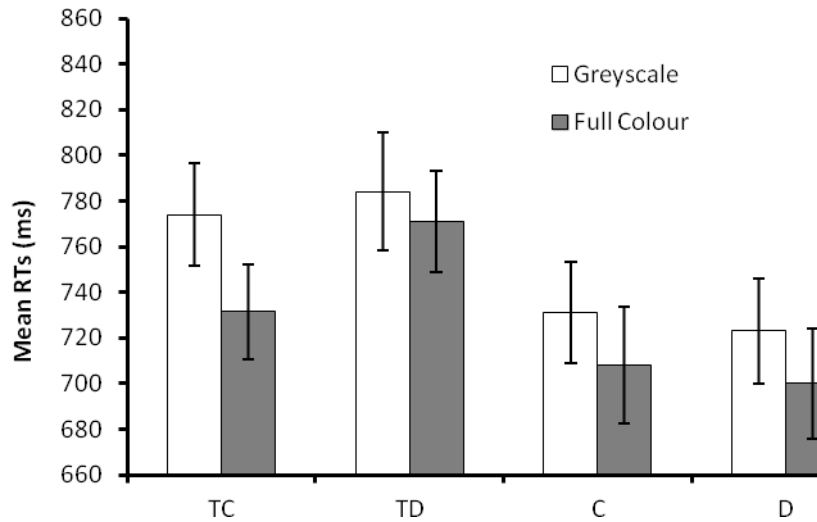


Figure 4.7. Mean reaction times (RTs) in the threat classification task, Experiment 12 (TC-threatening cats; TD-threatening dogs; C-Non-threatening cats; D-Non-threatening dogs. Error bars reflect within-participant standard errors.

the transformed scores showed that both the main effect of the valence, $F(1, 23) = 7.1$, $MSE = 0.062$, $p < .05$, and the main effect of the animal, $F(1, 23) = 20.1$, $MSE = 0.31$, $p < .001$, were statistically reliable. Participants responded to the non-threatening images more accurately than to the threatening images. Also, participants made fewer errors in responding to the cat images than to the dog images. There were no obvious signs of any speed/accuracy trade-offs in the data.

4.4.3. Discussion

Although statistically, the effects were slightly different across the two image formats (Full colour, Greyscale), the overall patterns of performance were generally the same. Generally speaking, participants found the threatening images more difficult to classify than the non-threatening images. This threat disadvantage rules out the possibility that the valence effects in the search tasks came about purely because the threatening images were easier to classify than the non-threatening images. The threat disadvantage is clearly a robust finding, being present in the data for the dog and the cat target trials and in the data for both image formats. Moreover, it is somewhat surprising given that it is the complete reverse of the valence effects

found in the search tasks in Experiments 10 and 11. Reasons for this particular contrasting pattern of effects are discussed in much more detail later.

All of the non-threatening images were of domesticated cats and dogs. All of the images of the threatening cats were of wild cats and most of the images of the threatening dogs were of wolves but some were of domesticated attack dogs. On these grounds, the main effect of threat in the single item classification tasks may reflect a familiarity effect (see Quinlan & Dyson, 2008, Chapter. 5) – with domesticated animals being more familiar to the participants than the wild animals were. Alternatively, the effect may reflect item typicality (Castelhana, Pollatsek & Cave, 2008; Rosch, 1975) – with the domesticated animals being more typical cats/dogs than the wild counterparts. Both of these possibilities provide ready explanations for the threat disadvantage effect in these single item classification tasks. Regardless of what the definitive factor is, it is the contrast between performance in these non-search tasks and the previous search tasks that is the more intriguing. Simply put, performance in search tasks could not have been predicted on the basis of the data found in the non-search versions of the tasks.

4.5. Experiment 13

Although the threat advantage was not due to that the threats are purely easy to be categorised. There are remained concerns about the possible confounding stimulus factors. On a more careful inspection of the target images, one such factor became apparent. In selecting the threatening target images the defining criteria were that the animals pictured snarling, and that the snarl was directed towards the viewer. Given this, the overwhelming majority of the threatening target images were of headshots of the animals. In contrast, and by necessity, because these criteria had not been applied to the selection of the non-threatening target images, there was much more variety in the poses of the animals captured in the non-threatening target images. There were 10 and 12 headshots of the non-threatening cats and dogs, respectively, and 34 and 38 headshots of the threatening cats and dogs, respectively. Therefore, maybe, the presence of the target was easier to detect when a headshot was presented than when facial features in the image were not as salient. This is not an entirely speculative proposition given that, at least, when human faces are used,

participants are able to extract emotional expression information rapidly from images of faces presented in peripheral vision (see Calvo & Nummenmaa, 2008; Calvo, Nummenmaa & Avero, 2010; Goren & Wilson, 2006; Haberman & Whitney, 2007).

In a bid to address this possibility, more careful selection of the non-threatening target images was undertaken. Experiment 13 mapped onto Experiments 10 and 11. Controls were undertaken to match up the threatening and non-threatening targets so that in both cases the facial features and general pose of the animals in the images were similar. The original threatening images used in the prior experiments were retained, but matching to these images was undertaken in selecting the new non-threatening target images.

4.5.1. Method

In all respects, except stimuli and participants, Experiment 13 was the same as Experiments 10 and 11. In this case the threatening images were as before and new non-threatening images were chosen so as to control for general pose across the image sets.

Participants

Twenty-four naive participants (mean age = 21, 17 female) were recruited from students of York University. There were five left-handed individuals. They received either a course credit or £4. All of the participants reported normal or corrected-to-normal vision.

4.5.2. Results

4.5.2.1. Detection task

The same methods of data analysis used before were used here. Figure 4.8 shows the search functions for the four target types together with the Absent trials. Initially interest is with the data for the Present trials.

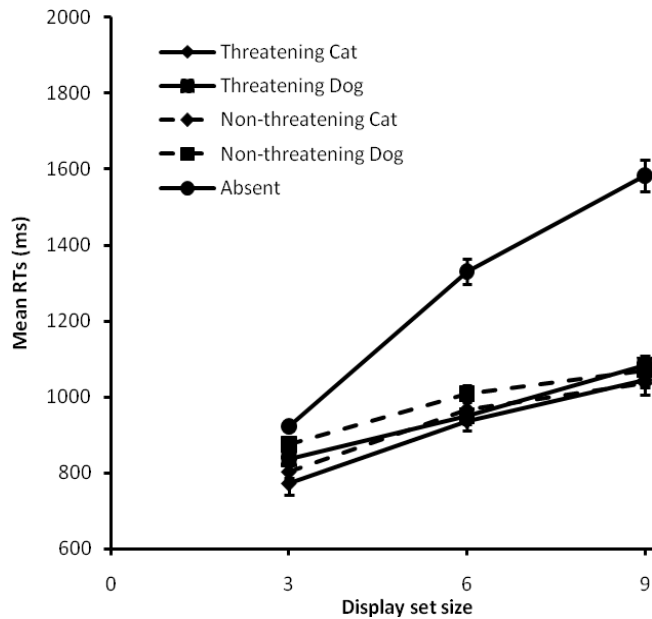


Figure 4.8. Mean reaction times (RTs) in the detection task, Experiment 13. Error bars reflect within-participant standard errors.

Present trials.

RTs.

The analysis revealed statistically significant main effects of valence, $F(1, 23) = 5.8$, $MSE = 6663$, $p < .05$, animal, $F(1, 23) = 10.7$, $MSE = 12759$, $p < .05$, and display size, $F(2, 46) = 99.8$, $MSE = 13686$, $p < .001$. No other tests reached statistical significance.

The main effect of valence revealed an overall threat advantage in the data: performance on the threatening target trials was more efficient than it was on the non-threatening target trials. However, by controlling the low-perceptual factors (e.g. pose), the threat advantage seemed decreased in Experiment 13 compared with the advantage shown in Experiments 10-11. Performance was also more efficient on the cat target trials than the dog target trials, and decreases in RTs scaled with increases in display size.

Error rates

Analysis of the transformed error scores revealed statistically significant main effects of animal, $F(1, 23) = 4.7$, $MSE = 0.054$, $p < .05$, and display set size, $F(2, 46) = 4.8$, $MSE = 0.58$, $p < .05$, no other tests were statistically reliable. The main effect of animal revealed that participants were more accurate in detecting the cat targets than the dog targets. The main effect of display set size showed that accuracy decreased monotonically as display set size increased. When considered alongside the RTs, there is no evidence of any systematic speed/accuracy trade-offs.

Absent trials.

Analysis of the RTs scores revealed that, although the Absent search function was well fit by a linear trend, $F(1, 23) = 201.16$, $MSE = 26914$, $p < .001$, for the linear component, as in Experiments 1 and 2, the departure from linearity was also statistically reliable, $F(1, 23) = 8.96$, $MSE = 7859$, $p < .01$, for the quadratic component.

4.5.2.2. Classification task

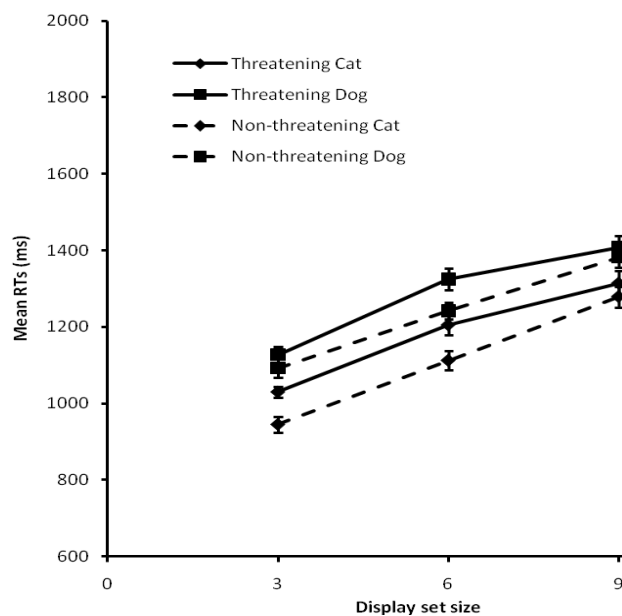


Figure 4.9. Mean reaction times (RTs) in the classification task, Experiment 13. Error bars reflect within-participant standard errors.

RTs.

Figure 4.9. shows the RTs from the trials for the four target types. Analysis revealed statistically significant main effects of valence, $F(1, 23) = 11.8$, $MSE = 21627$, $p < .001$; and the main effect of animal, $F(1, 23) = 28.1$, $MSE = 33951$, $p < .001$, and display size, $F(2, 46) = 122.2$, $MSE = 17511$, $p < .001$.

In this case, the most striking thing was that the main effect of valence was quite unlike those reported previously in the search versions of the classification task, because now the effect was manifest as a threat disadvantage: performance was faster on non-threatening target trials (mean RT was 1176ms) than it was on threatening target trials (mean RT was 1235ms). Subsidiary to this general pattern, the main effect of animal revealed that performance was better on cat target trials (mean RT was 1148ms) than on dog target trials (mean RT was 1263ms).

Error rates

Analysis of the transformed error scores revealed statistically significant main effects of valence, $F(1, 23) = 38.4$, $MSE = 0.061$, $p < .001$. No other tests were statistically reliable. The main effect of valence revealed that participants were more accurate in classifying non-threatening images than the threatening ones. There was no evidence for any systematic speed/accuracy trade-offs.

4.5.3. Discussion

Comparing across Figures 4.2, 4.4 and 4.8 it clearly is the case that the threat advantage in the detection tasks varied dramatically across the two stimulus samples. When more careful controls were undertaken, as in Experiment 13, so that the general pose of the animal in the picture was matched across the threatening and the non-threatening sets, then the size of the threat advantage decreased dramatically. What this shows is that, when possible, visual confounds across the threatening and non-threatening targets were more tightly controlled, then the effects of “threat” were, accordingly, attenuated.

This pattern of results leads to the consideration of the nature of the threat advantage in a more critical way. Previously, the presence of the threat advantage

was driven by the efficient detection of the snarling facial features. However, when the salience of facial features *per se* was equated across the threatening and non-threatening cases, then the size of the threat advantage decreased accordingly.

Aside from this, the most striking patterns of performance relate to the data from the classification task. In this case, for the data associated with both dog and cat targets, participants were less efficient in responding to the threatening targets than the non-threatening targets. The data revealed robust reverse effects of threat. Indeed, such a reverse pattern contrasts with the threat advantage found in the corresponding detection task. Whereas there was a threat advantage when participants responded to the presence of a distinctive target, there was a reverse threat effect when participants were asked to search for and classify the distinctive target. In this respect the effects of threat in the detection task dissociate from the effects of threat in the classification task.

Before discussing this pattern of performance in more detail, the new sample of images used in Experiment 13 was tested in Experiment 14, which mapped on the single item classification task as used in Experiment 12. Again, comparisons across the search and non-search tasks were useful to see whether performance in the non-search cases provided insights into performance in the search tasks.

4.6. Experiment 14

4.6.1. Method

In the final experiment a new sample of participants were tested in a partial repeat of Experiment 12. Now the full colour images used in Experiment 13 were used in a task that replicated the full colour condition in Experiment 12.

Participants

Twenty four naive participants (mean age = 21, 20 female) were recruited from students of York University. There were three left-handed individuals. They received either a course credit or £4. All of the participants reported normal or corrected-to-normal vision.

4.6.2. Results and discussion

4.6.2.1. Animal classification task

Figure 4.10 shows the RTs from the four types of target images. The analysis revealed statistically significant main effects of valence, $F(1, 23) = 38.5$, $MSE = 2186$, $p < .001$, and animal, $F(1, 23) = 14.2$, $MSE = 2642$, $p < .05$. In addition, the interaction between valence and animal was also statistically reliable, $F(1, 23) = 5.9$, $MSE = 1248$, $p = .001$. An HSD test examining the nature of the interaction revealed that performance was worse overall with the threatening targets than the non-threatening targets and the size of this effect was larger in the cat target trials than the dog target trials. Although the difference between threatening cat and dog targets was not statistically reliable ($p > .05$), performance was best overall with the non-threatening cat targets (all $ps < .05$).

Error analysis revealed a statistically significant main effect of valence, $F(1, 23) = 65.9$, $MSE = .022$, $p < .001$. Participants made more errors in the responses to the threatening images than to the non-threatening images. There was no systematic speed/accuracy trade-offs in the data.

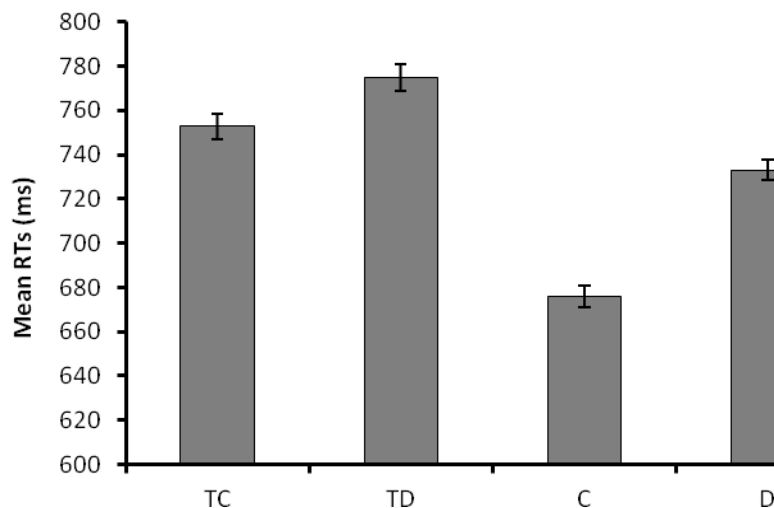


Figure 4.10. Mean reaction times (RTs) in the animal classification task, Experiment 14 (TC-threatening cats; TD-threatening dogs; C-Non-threatening cats; D-Non-threatening dogs). Error bars reflect within-participant standard errors.

4.6.2.2. Threat classification task

Figure 4.11 shows the RTs from the four types of target images. The analysis revealed statistically significant main effects of valence, $F(1, 23) = 7.9$, $MSE = 3005$, $p = .01$, and animal, $F(1, 23) = 36.5$, $MSE = 1900$, $p < .001$. In addition the interaction between valence and animal was also statistically reliable, $F(1, 23) = 7.5$, $MSE = 869$, $p < .05$. An HSD test revealed that participants responded to the threatening dogs faster than the non-threatening dogs. However, this valence effect did not reach statistical significance between threatening cat targets and non-threatening cat targets ($p > .05$). Also, threatening cat images were responded to faster than the threatening dog images; and no such difference was statistically reliable between the non-threatening cat images and non-threatening dog images.

Error analysis revealed a statistically significant main effect of animal, $F(1, 23) = 38.6$, $MSE = .02$, $p < .001$. Participants made more errors in the responses to the dog images than to the cat images. The valence effect on the accuracy did not reach statistical significance ($p > .05$).

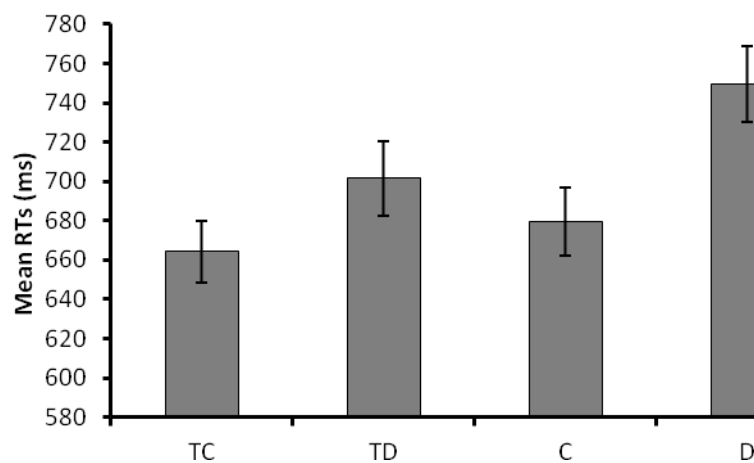


Figure 4.11. Mean reaction times (RTs) in the threat classification task, Experiment 14 (TC-threatening cats; TD-threatening dogs; C-Non-threatening cats; D-Non-threatening dogs). Error bars reflect within-participant standard errors.

In summary, the pattern of results in the animal classification task is consistent with the finding in the animal classification task in Experiment 12, and highly similar to those at each display size in the search version of the classification task in Experiment 13. In these tasks, the threatening targets were responded to faster

than that of the non-threatening targets. Interestingly, opposite to the results in the threat classification task in Experiment 13, the current finding in threat classification task is that the threat could facilitate the performance in some cases. The possible reasons for these are included in the General Discussion.

4.7. General Discussion

A series of experiments have addressed the issue of how the threatening content of images affects performance in a number of speeded detection and classification tasks. In the following, the discussion starts from performance in the detection and classification tasks separately and then moves on to discuss a general account that address the comparable and contrasting patterns of performance across the different tasks.

Performance in the detection tasks

In each of three experiments (Experiment 10, 11, 13), performance in speeded oddball versions of visual search has revealed a threat advantage: Participants were more efficient detecting a target image if the image depicted a threatening animal than if it depicted a non-threatening animal. This threat advantage was present regardless of whether the images were presented in full colour or in greyscale and it arose even though the threat content of the images was irrelevant to the task. As the threat advantage was present in both image formats, the effect arose because of the rapid pick-up of distinctive colours that were associated with the targets- this possibility was ruled out. Although the size of the threat advantage did decrease when greyscale images were used, the fact that the effect survived when the images were presented in greyscale suggests that colour cues do not play a critical role in the effects of threat described by LoBue and DeLoache (2011).

The argument was that the threat advantage in the detection tasks came about because all the threatening targets contained images of snarling animals. Furthermore, it was because of an attentional sensitivity to this facial configuration that the detection of threatening targets was relatively efficient. This claim was

tested further in the final two experiments in which more careful controls were introduced in the selection of the non-threatening targets. Across the original target sets there was an apparently confounding distinctive visual characteristic of the threatening images. In the threatening target sets, the images were overwhelmingly of headshots of the animals and this was not true for the non-threatening images. Consequently, in the final experiments a new set of non-threatening images were selected so that the animals in both threatening and non-threatening images were more closely matched in terms of headshots and pose.

When these new stimuli were used in the detection task, although the size of the threat advantage was considerably smaller than found previously, it was nevertheless still statistically robust. On these grounds, to a large part, the original threat effects in the detection tasks may well have reflected the rapid detection of the face of an animal in the visual periphery. The effects apparently reflect the ease of detection of facial features *per se* rather than a particular sensitivity to detecting a snarling animal. Having controlled for this possibility in Experiment 13, the effect of threat was still apparent in the data. Although participants were consistently more efficient in responding in the presence of a threatening than a non-threatening target, detection of the threatening targets did not conform to the operational definition of automaticity, search slope should be less than 5-6 ms/item (Treisman & Souther, 1985), therefore the evidence does not full fit the fear response hypothesis and the associated claim that people are, in some sense, perceptually tuned to detect the presence of immediate visual threats (cf. Öhman, 1999). The visual threat, in this case, was conveyed by the image of a snarling animal.

Performance in the classification tasks

Performance has been examined in both search and non-search versions of the classification tasks. In both, and on every trial, participants had to judge the category (either cat or dog) of the target image. In all of the experiments there were clear differences in the effects across the detection and classification tasks. There were cases where the threat advantage found in the detection task did not mirror in the data for the classification task. In addition, completely contrasting effects of threat were found in the two tasks. These particular kinds of dissociation are

consistent with another aspect of the fear hypothesis, namely, that a threat can be detected even though the nature of that threat has not been recovered.

In this regard, the current data stand in contrast to the claim that “as soon as you know it is there, you know what it is” (Grill-Spector & Kanwisher, 2005). The main evidence for this claim comes from various experiments, but most relevant results were from a case in which participants were presented on every trial with a centrally briefly presented and masked photographic image of a real world entity. Performance was tested in three separate conditions. In the detection condition, on half the trials the target contained a scrambled image such that the identity of the original item was unrecognizable. On the remaining trials, an un-doctored image was presented. Participants were simply asked to make an object/non-object decision. In the classification condition, only original images were used and participants were asked to provide the category name of the pictured entity (e.g., face, bird, dog, etc.). Finally, in the identification condition, participants were asked to provide a subordinate level label such as Harrison Ford, Pigeon, German Shepherd, etc.

Accuracy was mapped out as a function of the image duration and a central result was the functions for the detection and classification task were essentially identical. Hence the claim that, even in the detection case, the participants had recovered the item’s categorical status. As the rise time of the function for the identification condition was slower than the other two cases, the additional claim was that object identification slows detection and classification.

The present data do not fit comfortably with those reported by Grill-Spector and Kanwisher (2005). Here results showed that participants were able to detect the presence of a threat item in the absence of having recovered the category of that item. Participants, in a sense, knew the target was there, but they did not know what it was. On these grounds, the contrasting patterns of performance across the two studies may reflect the differences in the demands of search and non-search tasks. In the paradigm described by Grill-Spector and Kanwisher (2005), participants fixated centrally and all of the images were presented centrally. The conclusions drawn by Grill-Spector and Kanwisher (2005) may, therefore, only apply when participants are not actively engaged in a search task. In addition to, or alternatively, the contrasting pattern of effects across the two studies may reflect something critical about the

different operations associated, respectively with central and peripheral vision. Only future work will be able to tease these accounts apart. At the very least, and on the basis of the present data, it seems that it is not generally true that “as soon as you know it is there, you know what it is”.

Another central result is the clear dissociation in the effects across the animal classification tasks and the threat classification tasks. The animal classification tasks were run in search versions and non-search versions. In the search version of the tasks of Experiments 10 and 11, either the effects of valence were not present (as was the case for dog target trials) or there was a reliable threat advantage (as was the case for the cat target trials). In Experiment 13, however, the effects of valence were expressed as a threat *disadvantage*. Participants were less efficient in classifying the threatening images as cats and dogs than they were in classifying the non-threatening images. The threat disadvantage was robust in the non-search versions of the task (Experiments 12 and 14). The threat classification tasks were only run in the non-search versions. The threat disadvantage occurred in Experiment 12, but interestingly, there was the opposite effect in Experiment 14. Participants responded to the threat faster than the non-threats.

The targets were presented at the same peripheral locations in all cases. The contrasting patterns suggest the valence effect varies depending on several factors, such as task requirements, search/non-search and familiarity or typicality of the targets.

A general account of performance in the detection and classification tasks

In the speeded detection tasks, participants could respond on the basis of any salient visual cue that distinguished the target from the non-target images. Such target cues may either be defined in terms of (i) perceptual valence or (ii) emotional valence (cf. Huang & Yeh, 2011). Image colour was ruled out as being a useful target cue in the current tasks. However, it does seem that the presence of a salient facial configuration in the periphery may have served as a potent target cue in the first two experiments. Given this, the remaining concerns were with whether any valence effects were due to target cues defined in terms of emotional valence. In this

regard, the results of Experiments 13 and 14 do suggest that participants were particularly sensitive to the presence of a snarling animal. That is, the data suggest that participants showed a further sensitivity to the presence of the facial cues that define a snarl. This conclusion fits relatively well with the fear response hypothesis (Öhman, 1999).

In other respects, though, the evidence does not fit so well with the hypothesis. For instance, there is no evidence here for the *automatic* detection of such threat cues. On the contrary, what the current data suggest is such cues can enhance the guidance of attention to a potential target. Therefore, the attentional system is sensitive to target cues that are either perceptually salient, emotionally salient or, indeed, both. In the present case, emotional valence has been defined in terms of a particular configuration of facial features that define snarling.

This evidence sits relatively comfortably with that reported by Calvo and Nummenmaa (2008). They examined performance in an extensive series of experiments in which speeded oddball detection tasks were used. In the initial cases, the displays contained a central facial image surrounded by six other peripheral facial images and the task was to judge whether the faces all portrayed the same expression or whether a discrepant expression was present. A key finding was that participants were particularly good at detecting the presence of a happy expression. Further experiments allowed Calvo and Nummenmaa (2008) to conclude that the critical facial cues were associated with the visual salience of the mouth. The present data are consistent with these ideas insofar as the critical cues to a snarl are also defined in terms of the mouth.

Comparing across the search versions of the detection and classification tasks, it seems more appropriate to consider the possibility of two attentional pathways. Such a framework was described by Wolfe, Võ, Evans, and Greene (2011). The claim is that the human visual system as comprised of a *selective* and a *non-selective pathway*. According to Wolfe et al. (2011), the non-selective pathway is, essentially, free of capacity limitations and operates by extracting, “statistical information rapidly from the entire image” (p. 81). According to the two-pathway account, it is the operation of this system that is predominantly reflected in the results from our detection experiments. It is the non-selective system that is able to extract salient

target cues rapidly from the periphery. An assumption is that such cues provide a very crude specification of the kinds of objects present in the scene (such as natural vs. man-made, see Wolfe et al., 2011).

In contrast, the selective pathway has associated capacity-limitations and is primarily responsible for object identification. Extraction of information about the categorical nature of the targets is associated with the operation of the selective pathway. A related claim is that whereas object identification is a relatively time-consuming process, the recovery of scene gist on the non-selective pathway can be carried out much more rapidly. In addition, Wolfe et al. (2011) claimed that both pathways work in tandem, such that the rapid recovery on the non-selective pathway can guide the attentional operations on the selective pathway. Indeed, it is the interactive nature of the two pathways that may explain the patterns of performance in the search versions of the classification experiments reported here.

The assumption was that performance in the detection experiments predominantly reflects the operation of the non-selective pathway. It is this pathway that is able to recover, relatively rapidly, the presence of a salient facial configuration in Experiments 10 and 11. Given that such cues were positively correlated with the threat category distinction, then the basic threat advantage in these cases is consistent with the idea that it is a sensitivity to the *perceptual* salience of the threatening targets that is being revealed in these cases. In contrast, in Experiment 13 when perceptual salience was controlled for across the threatening and non-threatening targets, the threat advantage was reduced considerably. However, given that the advantage still occurred, this was evidence that there is an attentional sensitivity to the presence of visual cues associated with threat. Furthermore, it is this pathway that is activated by any salient threat cues in the scene such as the “snarling” cues associated with the threatening animals that have examined here. The rapid activation of the non-selective pathway and the slower activation of the selective pathway provides a ready explanation of how it can be that a target is detected in the absence of knowing what that target is (see Wolfe et al., 2011; p. 82 for more on this point).

Performance in the classification tasks demands a more complicated account. Object classification is primarily due to the operation of the selective pathway and

the properties of this system are directly revealed in the data for the *non-search* versions of the animal classification tasks examined here. In all such cases, the data reveal a reverse effect of threat: Non-threatening targets were classified more easily than threatening targets. Interestingly, the results in the threat classification were not always consistent. The threat disadvantages still occur in the Experiment 12, but the reversed effect occurred in Experiment 14. Combining these results, the valence effect on the classification was complex, depending on task requirements as well as perceptual factors.

This pattern, however, was not present in the data for the *search* versions of the classification tasks in Experiments 10 and 11. At the small display sizes the difference in performance with the threatening and nonthreatening targets was essentially abolished; it was only at the larger display sizes that the effects of threat began to emerge (and here only in the data for the cat target trials). This suggests that, in these searches, performance reflects a variety of different factors that are differentially associated with each of the two pathways and may be in competition with one another.

It is possible to think that that performance in the tasks may reflect the operation of either or both of the pathways, depending on the completion times of information recovery on each pathway. Generally, the non-selective pathway will complete first, but the attentional guidance provided by this pathway in the context of search may *not* then facilitate the process of object identification carried out by the selective pathway. The threat advantage in the data from the detection tasks, contrasts with the reverse effects of threat in the data for the single item classification tasks. Therefore, although the non-selective pathway favoured the threatening targets (because these were perceptually salient), the selective pathway favoured the non-threatening targets (because these were more familiar/more typical).

The nature of these conflicting tendencies is revealed in the data for the search versions of the classification tasks in Experiments 10 and 11. At the smallest display size these two opposing tendencies cancelled each other out, whereas at the largest display size the operation of the non-selective pathway was most apparent. If the non-selective pathway primarily operates by integrating information across the whole display (Wolfe et al. 2011), it is also sensible to suggest that characteristics of

this system will be most apparent at the largest displays sizes when grouping processes come to the fore (see Humphreys, Quinlan & Ridloch, 1989).

By controlling the perceptual salience of the threatening and non-threatening targets, different patterns of performance arose in Experiment 13. Under these circumstances, the threat advantage was considerably reduced in the detection task and a reverse effect of threat arose in the data for the classification search task. This reverse threat effect was the same as that shown in the non-search version of the classification task and was present at all display sizes.

The data in the search version of the classification task in Experiment 13 may solely reflect the operation of the selective rather than the non-selective pathway. This is because when the perceptual salience between the threatening and non-threatening targets was no longer so marked, then the processes of object classification no longer benefited from the guidance provided by the non-selective pathway. The data from the detection task suggest that the delay between the recovery of information regarding the non-threatening and threatening targets on the non-selective pathway was considerably reduced. A consequence of this was that the attentional guidance provided by the non-selective pathway no longer conveyed an advantage to the processing of the threatening targets on the selective pathway. Under these circumstances, factors concerning the semantic analysis of the target image now came to the fore and it was these that determined the efficiency of the classification process.

Fundamental to the account is the assumption that the two pathways operate concurrently and in tandem, such that a response can be made on the basis of information accumulated from either or both of the pathways. Additionally, information recovered by the non-selective pathway provides attentional guidance that can affect the operation of the selective pathway (cf. Wolfe, et al., 2011). In the cases where target detection can be based on the rapid recovery of a crude specification of the target, then performance reflects the operation of the non-selective pathway. Where there are such differences in perceptual salience between the different targets types, then it seems that effects found in the detection task are reflected in performance in the search version of the classification task (as in Experiments 10 and 11). In cases where the difference in the perceptual salience

between the threatening and non-threatening targets is no longer as marked (as in Experiment 13), then performance in the classification tasks now reflects semantic factors and not target salience.

4.8. Conclusions

The present findings fit comfortably within a framework for thinking based on assumptions about the operation of two attentional pathways (cf. Wolfe et al., 2011). From the current speeded detection task, performance primarily reflects the operation of the non-selective pathway and the recovery of saliency cues associated with the target. Cues in terms of perceptual salience and in terms of emotional salience (cf. Huang & Yeh, 2011) were discussed. The perceptual salience of the targets, to a large part, was responsible for the threat advantage in the detection tasks.

When the difference in the perceptual salience of the threatening and non-threatening targets was reduced, a correspondingly smaller threat advantage was present in the detection data. Reverse effects of threat were witnessed in the data for both the non-search and the search versions of the classification tasks. Performance on the classification tasks predominantly reflects the operation of the selective pathway, unless the rapid recovery of target information on the non-selective pathway facilitates the classification of perceptually salient targets.

Evidence has also been provided for the claim that a visual threat can be detected in the absence of having full knowledge of the nature of that threat. This too is explained in terms of differences in the information retrieval processes on the two attentional pathways. Typically, the rapid activation of the non-selective pathway is responsible for target detection, whereas slower activation of the selective pathway is responsible for target classification.

Chapter 5 General discussion

5.1. Summary

Three experimental chapters have addressed relationships between the presentation of visual threat and attention. Three relevant hypotheses were tested. First of all, threat was hypothesised to have an association with avoiding behaviours. Previous studies claimed that threatening stimuli were responded to faster by avoiding them than approaching them. In contrast, positive stimuli were found to be responded to faster by approaching them than avoiding them. These are known as ‘affective mapping effects’. In Chapter 2, the affective mapping effects were tested with a view to answering the question of whether there is evidence to support these claims by manipulating motor movements, particularly whether there are specific associations between the motor systems and the processing of visual threat.

The second hypothesis that has been tested is related to spatial attention. There is a current debate on whether threat presented at the focus of attention restricts the scope of attention. A series of flanker experiments were run and these aimed to reveal ‘flanker compatibility effects’. To demonstrate flanker compatibility effects, comparisons were made between the RTs in responses on compatible trials (in which the targets and flankers were congruent) and the RTs in responses on incompatible trials (in which the targets and flankers were incongruent). If the difference between compatible and incompatible conditions were statistically significant, this would indicate that congruent flankers facilitated the responses to targets; and this would constitute evidence for the occurrence of flanker compatibility effects. The occurrence of flanker compatibility effects is important for the ‘threat narrows attention’ account, because it was predicted that if threatening targets restrict attention, not enough attentional resources could be used to process the information outside the focus of attention. Therefore, congruent flankers could not speed responding to targets and the flanker compatibility effects do not occur. In contrast, as non-threatening targets do not restrict attention, the flanker compatibility effects were expected to occur. The experiments in Chapter 3 aimed to test whether the flanker compatibility effects occurred in the non-threatening cases, but not in the threatening cases. More importantly, an attempt was made to answer a crucial

question, namely can we claim that the stimuli valence is the actual factor influencing the occurrence of flanker compatibility effects?

The final hypothesis that was tested in Chapter 4 relates to the ‘threat detection advantage’. In previous studies, threat was found to be detected faster than non-threat in visual search experiments. For example, according to Öhman (1999) humans have evolved to detect threats in the immediate visual environment rapidly and automatically. However, following the ground breaking work by Öhman (1999), more and more studies have challenged the basic threat advantage. There is a debate on whether the so-called threat advantage is automatic or not; furthermore, there is a disagreement on whether the revealed threat advantage is due to the stimuli negative valence or simply due to the salient low-level perceptual features of the stimuli (e.g., shape). In the current experiments, to control for potential stimuli confounds, images of threatening cats and dogs and images of non-threatening cats and dogs were selected as innate stimuli of potential danger versus safety, respectively.

Apart from controlling stimuli factors, the factor of ‘task requirement’ was manipulated as well. Two tasks were used throughout the thesis. In the animal classification task (non-valence judgement task), participants were required to classify whether the target images were the images of cats or the images of dogs. In the threat classification task (valence judgement task), participants were required to classify whether the targets images were threatening or non-threatening. Threat was task-irrelevant in the animal classification task, and was task-relevant in the threat classification task. The reason for including both non-valence and valence judgement tasks was to test the ‘automaticity’ in threat processing. Although Öhman (1999), claimed that threat is processed and influences performance automatically, some studies found that threat only influenced performance when the task instructions encouraged participants to process the stimuli valence (e.g. Estes & Verges, 2008; Huang & Yeh, 2011).

Summary of main findings

The main findings in each chapter are as follows. In Chapter 2 no affective mapping effects were found. However, threatening targets were responded to more slowly than non-threatening targets in the animal classification tasks. In contrast, threatening targets were found to be responded to faster than non-threatening targets

in the threat classification tasks. Cat images were responded to faster than the dog images in the threat classification tasks.

In Chapter 3 no evidence was found for the account that threat narrows down attentional scope. What was found, however, was a fast same effect. Responses were faster when the images of the target and flankers were identical than in all other cases. However, there were no convincing flanker compatibility effects, when the images of the target and flankers were congruent but different. Threatening targets were responded to more slowly than the non-threatening targets in the animal classification tasks; this is consistent with the findings in Chapter 1. Cat images were found to be responded to faster than the dog images in the threat classification tasks in Experiments 6-7. In the location judgement task of Experiment 9, participants responded to the targets faster when the targets and flankers were presented in the same row than when they were in different rows; this was a location congruency effect.

In Chapter 4, in the detection tasks, threatening targets were detected faster than the non-threatening targets. However, the magnitude of the detection advantage was reduced after manipulating key stimuli factors (e.g., matching the number of head shots in threatening, non-threatening pictures). Performance in the animal classification tasks varied across the different experiments. Faster responses to the threatening targets were found in Experiment 10 (in the search task); however, slower responses to the threatening targets were found in Experiments 12-14 (in both search and non-search tasks). In the threat classification tasks, participants responded to the threatening images more slowly than to the non-threatening ones in Experiment 12, but faster in Experiment 14 (both these two experiments are non-search tasks). The results from the detection tasks are relatively consistent and the results from animal classification tasks and threat classification tasks were not clear cut.

In summary, across the three experimental chapters the consistent findings are that: (1) participants responded to the threatening stimuli more slowly than the non-threatening stimuli in the non-search animal classification tasks (Experiments 1-3, Chapter 2; Experiments 5-8, Chapter 3; Experiments 12, 14, Chapter 4). (2) In the

visual search detection tasks, participants detected threatening stimuli faster than non-threatening stimuli (Experiments 10-11, 13, Chapter 4).

Nonetheless, there are some puzzling findings. In the threat classification tasks, when only one image was presented on the screen, participants responded to threatening stimuli faster than non-threatening stimuli in some cases (Chapter 2; Experiments 14, Chapter 4), but more slowly in other cases (Experiment 12, Chapter 4). Cat images were found to be responded to faster than the dog images in the threat classification tasks in some cases (Experiments 1-3, Chapter 2; Experiments 6-7, Chapter 3), but not all.

The discussions are mainly on the basis of two consistent findings (see above). A general issue to be addressed is whether threatening stimuli could influence task performance. Moreover, the relationship between motor actions and threat, the relationship between spatial attention and visual threat will be briefly discussed. Finally, there is a general conclusion for this thesis.

5.2. Responses to the visual threat

Does threat impair task performance?

Before addressing the issue of whether threat impairs task performance or not, it is useful to describe two studies, which help to form a starting point for the discussion. These two studies are both related to the term ‘task relevance’. As described in Chapter 2, Estes and Verges (2008) claimed a response-relevance hypothesis, which is based on the assumptions that threat captures attention quickly and attention is difficult to be disengaged from threat. The hypotheses are that when threat is task relevant, no attentional disengagement was required from the stimuli valence, threat can hold attention and be responded to relatively faster than non-threat. When threat is task irrelevant, attention must be disengaged from the stimuli valence. As disengagement is slow, responding on threat is evoked more slowly than those on non-threat. According to the response-relevance hypothesis, threat can impair task performance when it is task irrelevant.

Estes and Verges (2008) tested this hypothesis in a lexical decision task, in which participants were required to judge whether each letter string was a word or a non-word (threat is task irrelevant) and a valence judgement task, in which participants were required to judge whether each word was positive or negative (threat is task relevant). They found that threatening words (e.g. spider) elicited slower lexical decisions but faster valence judgments; this result strongly supported their hypothesis.

Another relevant study was conducted by Huang and Yeh (2011). They used both emotionally and perceptually salient stimuli and they manipulated the task requirements to encourage the processing of perceptual features (e.g. colour, Experiment 1) or to encourage the processing of emotional valence (Experiment 2). Participants needed to judge the direction of the gap of a rectangular Landolt C border around one search image. The results showed that the stimuli valence impaired task performance, but this effect only occurred when the task encouraged the processing of stimuli content. The findings are consistent with other studies that showed the task-dependent nature of processing of emotional information (Huang, Baddeley, & Young, 2008; Stein, Zwickel, Ritter, Kitzmantel, & Schneider, 2009).

The above two studies both pointed to the importance of task relevance on threat processing. However, the claim that threat impaired performance is controversial. According to Estes and Verges (2008), threat impaired performance when it is task irrelevant (in the non-valence judgement task). In contrast, results from Huang and Yeh (2011) suggested that threat impaired performance when it was task relevant (when task requirements encouraged participants to process the stimuli content). The reason for this controversy is that 'task relevance' was defined in different ways. Estes and Verges (2008) restricted the phrase 'threat is task-relevant' to when participants needed to process threat in a valence judgement task. Huang and Yeh (2011) interpreted 'threat is task-relevant' to when the content of stimuli was encouraged to be processed, even in a non-valence judgement task. Another way to demonstrate the difference between Estes and Verges (2008) and Huang and Yeh (2011) is that threat is a target in the former case, and threat can be presented as a distracter in the latter one. To address whether threat impaired performance, the discussions will include evidence from studies, in which threat is the target, as well as evidence from studies, in which threat is a distracter.

We will begin with the cases where threat is the target. In the animal classification tasks (Experiments 1-3, 5-8, 12, 14), participants responded to the threatening targets more slowly than to the non-threatening targets. These results can be explained by the response relevance hypothesis, attention must be disengaged from the stimuli valence so as to judge the animal category of the stimuli, hence slow attentional disengagement caused slow responding. This sounds like a convincing evidence for ‘threat impaired performance’. However, there is an alternative explanation, which the current findings cannot rule out. Someone might argue that the difference between the responding on threatening targets and that on non-threatening targets is actually due to ‘familiarity’ of the depicted animals. There were four types of images selected as stimuli. The threatening cat images and threatening dog images were selected from wild animals, and the non-threatening cat images and non-threatening dog images were selected from domestic animals. The domestic animals live in our neighbourhoods, and we encounter these much more often than wild animals. As a consequence, domestic animals are much more familiar to the participants than wild animals. The more we are familiar with them, the more quickly we can identify them. In other words, the effects of threat are confounded with effects of familiarity.

Another advantage for the non-threatening animal images in the animal classification tasks is that we are ready to name them as a cat or a dog. This is slightly different from how we name the wild animals. For example, although tigers and lions are big cats, we do not name them as a ‘cat’. We call a tiger a ‘tiger’, not a ‘big cat’. Therefore, in the animal classification tasks, when the threatening images of the wild animals are presented, we do not readily classify them as cats or dogs as quickly as we do the domestic animals.

The next concern is whether we can find evidence for threat impaired performance when threat is presented as a distraction. Threatening distracters were presented prior to the targets (as a prime in Experiment 4; as flankers in Experiments 7-8), as well as simultaneously with targets (Experiments 5-6, 9). Only one piece of evidence of impaired performance was found in the location judgement task (Experiment 9), but it only occurred in the threatening dog target trials, and did not generalize to threatening cat target trials. Overall therefore, there was no convincing

evidence that threat impaired performance in cases where it acted as a potential distraction.

Based on the current findings, the answer to ‘Does threat impair task performance?’ is probably ‘no, there is no evidence to support the claim that any impairment of performance is due to threat’.

Does threat facilitate task performance?

The only finding that can be used to argue whether threat can facilitate task performance came from the current visual search experiments. The discussion addresses two issues. First, are the responses to threatening targets automatic? The slopes of the respective search functions in Chapter 4 indicate how RT varies with the number of items in a search display. One guiding principle often used to indicate automatic processing is that search slopes are less than 5-6 ms per item (e.g. Treisman & Souther, 1985), however, the current search slopes were generally larger than that. This result does not fit the fear response hypothesis (e.g. Öhman, 1999), namely that threat processing is carried out without conscious awareness and is conducted in parallel. Another way to test the ‘automaticity’ is to manipulate the task requirements. If the processing of threat is automatic, threat would influence performance no matter what the task requirements are. However, results from the current experiments vary across task requirements (as noted above). Therefore, there is no evidence to support the assumption of automatic threat processing in the experiments reported here.

Secondly, are threatening targets responded to faster than non-threatening targets? With regard to the speed of responses, we found that threat was detected faster than non-threat in Chapter 4; and this sounds like evidence for the argument that threat facilitates task performance. However, by manipulating stimuli factors (by matching the numbers of headshots presented in threatening, and non-threatening pictures), the threat detection advantage was reduced (in Experiment 13). Although there was still a threat detection advantage, the significantly decreased magnitude after manipulating low level perceptual information indicated that the threat

detection advantage may depend primarily on perceptual factors of stimuli rather than stimuli valence.

Although the evidence for threat detection advantage is tenuous in the present experiments, is there any more convincing evidence to be found in previous studies? A recent review of visual search studies (Quinlan, 2013) reported 14 published cases (e.g., Purcell, Stewart, & Skov, 1996) that failed to replicate the threat detection advantage. In addition, Quinlan (2013) evaluated empirical evidence from 23 published cases, which reported the threat detection advantage. However, he claimed that the advantage could be due to one or more methodological confounds. For example, target detection is easier when the non-targets are visually similar to one another than when the non-targets are visually dissimilar from one another. Furthermore, Quinlan (2013) also pointed out some of the most distinctive stimuli confounds, such as the animal/plant distinction (Tipples et al., 2002) and the snake-like, coiled shape (LoBue & DeLoache, 2011), which have not been well controlled in cases reporting a threat advantage. The review concludes on a skeptical note, namely that threat detection advantage is not at all convincing and such effects can be caused by uncontrolled confounds rather than stimuli valence.

Someone may argue that Quinlan's (2013) conclusion is extreme. Threat might benefit task performance, but this only occurs under restricted conditions. In other words, the argument is that if the conditions can be controlled properly, supportive evidence can be found for the threat detection advantage. However, the results from this thesis do not support this argument. When confounds were carefully controlled, the threat detection advantage was found essentially tied to either or both of stimulus and task characteristics.

Given that the stimuli factors influence threat processing, a question arose as to whether all the reported effects caused by threat are not reliable. In other words, are all the so-called valence effects actually due to low level perceptual factors? Before giving firm conclusions, the reported 'threat advantage' was traced further in the literature. Apart from the methodological and stimuli confounds, the reliability of threat detection advantage may be related to the sample of participants recruited in experiments. Some evidence shows that the threat detection advantage occurred in responses when participants felt that the targets were threatening, but not when they

felt the targets were non-threatening. For example, phobic participants tended to show increased threat detection advantage effects only for their feared animal and not others (Öhman et al., 2001). However, Purkis and Lipp (2007) found that the implicit evaluations of threatening stimuli did not influence the occurrence of threat detection advantage. In their study, spiders/snakes experts and non-experts were recruited. Non-experts were more fearful of snakes and spiders than cats and horses, whereas experts did not display a difference in fear levels. Participants detected the spiders and snakes faster than the non-threatening animals, regardless of their expertise. Purkis and Lipp (2007) concluded that the detection of threat is on the basis of low-level perceptual features.

The attitude towards stimuli possibly is not the reason for any detection advantage, but the level of trait anxiety might be. A comparison between participants who have different levels of anxiety found that high trait anxious (HTA) individuals were faster than low trait anxious (LTA) individuals in detecting angry faces in a neutral crowd (Hansen & Hansen, 1988; Byrne & Eysenck, 1995). The level of anxiety may influence responding to threatening stimuli and it may be useful to compare the performance between clinic and non-clinic participants in the future studies.

5.3. Motor actions and visual threat

The work reported in Chapter 2 addressed the issue of how motor responses relate to threat processing. The human organism has evolved to give precedence to signals of potential danger, associated with the need to avoid harm. Action tendencies correspond to the motivational systems for approach and avoidance, respectively (Lang et al., 1998). The aim in Chapter 2 was to test for affective mapping effects, in which threat is responded to faster by avoiding than approaching it. Threatening and non-threatening stimuli were presented in the central visual field. Approach and avoidance behaviour tendencies were triggered by arm movements and finger movements (key pressing/releasing).

Evidence from the experiments in Chapter 2 did not replicate the affective mapping effects. There was no statistically significant difference between the

responses to threat by approaching or avoiding. As discussed, one of the possibilities is that the arm movements, and finger movements required in the tasks did not effectively trigger the avoidance/approach behavioural tendencies. As with the presence of threatening animal images, escaping may be a natural response when facing biological threat; the body movements may be more reliable at triggering the avoidance behaviours. In further studies, body movements could be included as the required responses to biologically threatening stimuli. Possibly, the affective mapping effects could be replicated in a more natural setting.

5.4. The scope of attention and visual threat

The key issue in Chapter 3 was to explore the relationship between threat processing and spatial attention. According to Fenske and Eastwood (2003), central threat narrows down attentional scope. The flanker experiments in Chapter 3 aimed to test their claim. The ‘attention narrowing’ account was based on the comparison of flanker compatibility effects found in threatening target trials and those found in non-threatening target trials. The magnitudes of the flanker compatibility effects in the threatening target trials should be much smaller than those in the non-threatening target trials, because fixated threat narrows attentional scope and impairs the processing of flankers.

The first step was to test the reliability of the flanker compatibility effects with different materials, namely photographic images of animals. In the flanker paradigm, the target image was presented in the central visual field with flanker images on each side. In the current series of experiments, there was a fast same effect, in which participants responded to the targets faster when the targets and flankers were identical than when they were different. In cases where the targets and flankers were different, but congruent in one dimension (e.g., emotional valence), no flanker compatibility effects were found, regardless of the target stimuli valence.

However, no consistent flanker compatibility effects were found; therefore, there is no evidence to support the ‘threat narrowed attentional scope’ account. As discussed in Chapter 3, many studies challenge the claim that flanker compatibility effects are caused by emotional valence. For example, Horstmann, et al. (2006)

claimed the reported flanker compatibility effects were due to perceptual cues carried by stimuli rather than emotional valence. Therefore, the difference of flanker compatibility effects in threatening and non-threatening trials appears not to support the claim that ‘threat narrows attentional scope’.

The reliability of the flanker compatibility effects are essential for the ‘attention narrowing’ account. There is a fast same effect in the current experiments, but not consistent flanker compatibility effects. Questions arose as to whether the previous reported flanker compatibility effects are due to the valence congruency or whether they are actually the fast same effects, which are due to the presence of identical stimuli. Carefully examining the published studies (e.g., Fenske & Eastwood, 2003; Horstmann, et al., 2006), it was found that most of the flanker compatibility effects in the literature are cases where the targets and flankers were identical in the compatible conditions. This suggested that the flanker compatibility effects in these cases were actually the fast same effects.

Nonetheless, there is one notable exception: in the study by Zhou and Liu (2013) when they used male and female pictorial facial stimuli, a flanker compatibility effect occurred when the targets and flankers were different, but congruent in the dimension of valence. This is the only case that has demonstrated that flanker compatibility effects were caused by the congruency of the target and flanker valence. Interestingly, this effect only occurred when participants were required to judge the valence of the target faces, but not in the task requiring participants to judge the gender of the target faces. Moreover, there is no statistically significant difference between the magnitudes of the flanker compatibility effects in negative face target trials and those in positive, neutral face target trials. Therefore, even if there was a piece of evidence for flanker congruency effects, it does not support the claim that threat narrows down attentional scope. In future studies, it could be useful to examine whether emotionally facial stimuli influence performance differently from biological threats. Maybe facial stimuli have a special status and are unlike other biological objects in this regard.

5.5. Conclusion

This thesis has addressed how we process visual threat. The threat detection advantage (threatening targets were detected more quickly than non-threatening targets), the affective mapping effect (threat is responded to faster by avoiding than approaching), and the flanker compatibility effect (responses are faster when the targets and flankers are congruent than when they are incongruent) were tested in various paradigms by using threatening/non-threatening animal images. There was no robust evidence to support the claim that so-called threat-related effects were actually due to the threatening valence of the stimuli used. The current evidence from Chapters 2-4 suggests that the descriptions of threat-related effects may be misleading. The variations in task performance that were associated with the threat content of the stimuli appear to have been linked critically to stimulus factors and particular task requirements. In this regard, the thesis provides no support for the fear response hypothesis (Öhman, 1999). The null findings reported here do not preclude the possibility that humans preferentially process real biological threat when these occur. However, the experimental evidence for this claim remains to be collected.

APPENDICES

Table 1.

Mean Reaction Times (RT), Standard deviations (SD), and mean percentage error rates (%E) in the animal classification task in the Experiment 1.

Types of images	RT	SD	%E
Threatening Cat	765	127	6.2
Threatening Dog	750	126	2.6
Non-threatening Cat	677	103	2.3
Non-threatening Dog	676	95	1.9

Table 2.

Mean Reaction Times (RT), Standard deviations (SD), and mean percentage error rates (%E) in the threat classification task in the Experiment 1.

Types of images	RT	SD	%E
Threatening Cat	628	94	1.7
Threatening Dog	679	105	4.5
Non-threatening Cat	659	114	2.4
Non-threatening Dog	668	95	2.3

Table 3.

Mean Reaction Times (RT), Standard deviations (SD), and mean percentage error rates (%E) in the animal classification task in the Experiment 2.

	Approach (arm extension)			Avoidance (arm flexion)		
	RT	SD	%E	RT	SD	%E
Threatening Cat	986	178	3.4	1018	228	3.1
Threatening Dog	1007	201	1.4	1051	227	2.7
Non-threatening Cat	922	179	0.8	948	218	1.3
Non-threatening Dog	984	204	1.9	1015	196	1.3

Table 4.

Mean Reaction Times (RT), Standard deviations (SD), and mean percentage error rates (%E) in threat classification task in the Experiment 2.

	Approach (arm extension)			Avoidance (arm flexion)		
	RT	SD	%E	RT	SD	%E
Threatening Cat	996	152	0.5	1033	135	1.2
Threatening Dog	1023	188	3.5	1067	166	1.7
Non-threatening Cat	1086	168	0.7	1021	145	1.1
Non-threatening Dog	1112	164	1.3	1055	160	1.8

Table 5.

Mean Reaction Times (RT), Standard deviations (SD), and mean percentage error rates (%E) in animal classification task in the Experiment 3.

	Approach (Key pressing)				Avoidance (Key releasing)			
	RT	SD	%E(Go)	%E(NoGo)	RT	SD	%E(Go)	%E(NoGo)
Threatening Cat	613	97	4.9	8.7	635	108	5.0	10.2
Threatening Dog	625	103	1.3	5.6	624	106	3.8	5.9
Non-threatening Cat	573	99	0.9	1.4	568	76	3.1	3.3
Non-threatening Dog	589	83	0.4	2.3	592	90	1.7	4.7

Note. (Go) - Go trials; (NoGo) - No-go trials.

Table 6.

Mean Reaction Times (RT), Standard deviations (SD), and mean percentage error rates (%E) in threat classification task in the Experiment 3.

	Approach (Key pressing)				Avoidance (Key releasing)			
	RT	SD	%E(Go)	%E(NoGo)	RT	SD	%E(Go)	%E(NoGo)
Threatening Cat	464	80	3.0	2.3	484	66	1.3	3.9
Threatening Dog	482	79	9.0	3.8	497	65	1.9	7.0
Non-threatening Cat	506	75	1.3	1.4	546	96	2.6	3.1
Non-threatening Dog	531	81	0.9	3.3	564	87	1.7	2.8

Note. (Go) = Go trials; (NoGo) = No-go trials.

Table 7.

Mean Reaction Times (RT), Standard deviations (SD), and mean percentage error rates (%E) in the Experiment 4.

	Target "#"				Target "@"			
	RT	SD	%E(Go)	%E(NoGo)	RT	SD	%E(Go)	%E(NoGo)
Threatening Cat	309	19	0.9	3.9	313	29	0.4	5.6
Threatening Dog	310	17	1.0	5.8	315	26	0.5	5.9
Non-threatening Cat	312	16	0.4	5.8	310	32	0.9	4.7
Non-threatening Dog	308	19	3.0	3.8	307	25	0.5	4.1

Note. (Go) = Go trials; (NoGo) = No-go trials.

Table 8.

Mean RTs (ms), standard deviations (SD) and error rates (proportions) for the different flanker conditions in the animal classification task in Experiment 5.

Target type	Flanker conditions											
	Congruent Emotion						Incongruent Emotion					
	Animal congruent			Animal incongruent			Animal congruent			Animal incongruent		
	Mean	SD	Error rates	Mean	SD	Error rates	Mean	SD	Error rates	Mean	SD	Error rates
Threatening Cat	633	155	0.04	660	163	0.05	645	156	0.05	648	145	0.06
Threatening Dog	614	136	0.03	637	158	0.04	618	146	0.03	630	157	0.04
Non-threatening Cat	600	155	0.03	604	141	0.04	616	171	0.03	602	146	0.03
Non-threatening Dog	603	136	0.02	633	151	0.05	636	146	0.03	619	151	0.03

Table 9.

Mean RTs (ms), standard deviations (SD) and error rates (proportions) in the neutral and no flanker conditions in the animal classification task in Experiment 5.

	Neutral flankers			No flankers		
	Mean	SD	Error rates	Mean	SD	Error rates
Threatening Cat	632	173	0.04	608	138	0.04
Threatening Dog	626	156	0.06	605	141	0.03
Nonthreatening Cat	607	145	0.04	589	155	0.04
Nonthreatening Dog	630	155	0.05	592	147	0.03

Table 10.

Mean RTs (ms), standard deviations (SD) and error rates (proportions) from different flanker conditions in the threat classification task in Experiment 5.

Target type	Flanker conditions											
	Congruent Emotion						Incongruent Emotion					
	Animal congruent			Animal incongruent			Animal congruent			Animal incongruent		
	Mean	SD	Error rates	Mean	SD	Error rates	Mean	SD	Error rates	Mean	SD	Error rates
Threatening Cat	538	125	0.03	558	146	0.02	546	135	0.03	548	124	0.02
Threatening Dog	538	131	0.02	542	132	0.02	540	135	0.02	552	155	0.01
Non-threatening Cat	525	129	0.02	536	122	0.04	533	116	0.02	542	134	0.02
Non-threatening Dog	529	121	0.04	548	139	0.03	553	139	0.03	535	122	0.03

Table 11.

Mean RTs (ms), standard deviations (SD) and error rates (proportions) of the neutral and no flanker conditions in the threat classification task in Experiment 5.

Target type	Flanker conditions					
	Neutral flankers			No flankers		
	Mean	SD	Error rates	Mean	SD	Error rates
Threatening Cat	541	129	0.02	526	114	0.03
Threatening Dog	545	149	0.02	535	141	0.03
Non-threatening Cat	539	128	0.02	523	150	0.03
Non-threatening Dog	543	143	0.05	507	110	0.03

Table 12.

Mean RTs (ms), standard deviations (SD), and error rates (proportions) from the different flanker conditions of the animal classification task in Experiment 6.

Target type	Flanker conditions											
	Congruent Emotion						Incongruent Emotion					
	Animal congruent			Animal incongruent			Animal congruent			Animal incongruent		
	Mean	SD	Error rates	Mean	SD	Error rates	Mean	SD	Error rates	Mean	SD	Error Rates
Threatening Cat	739	224	0.12	762	220	0.1	739	216	0.11	766	259	0.13
Threatening Dog	769	251	0.1	770	244	0.14	781	268	0.08	759	234	0.09
Non-threatening Cat	706	236	0.04	699	202	0.05	700	211	0.04	709	210	0.04
Non-threatening Dog	712	225	0.05	699	208	0.05	704	214	0.06	698	187	0.07

Table 13.

Mean RTs (ms), standard deviations (SD), and error rates (proportions) in the neutral and no flanker conditions in the animal classification task in Experiment 6.

Target type	Flanker conditions					
	Neutral flankers			No flankers		
	Mean	SD	Error rates	Mean	SD	Error rates
Threatening Cat	756	256	0.13	750	267	0.13
Threatening Dog	741	234	0.09	756	238	0.09
Non-threatening Cat	684	205	0.04	681	222	0.05
Non-threatening Dog	681	206	0.05	678	191	0.05

Table 14.

Mean RTs (ms), standard deviations (SD), and error rates (proportions) from the different flanker conditions in the threat classification task in Experiment 6.

Target type	Flanker conditions											
	Congruent Emotion						Incongruent Emotion					
	Animal congruent			Animal incongruent			Animal congruent			Animal incongruent		
	Mean	SD	Error rates	Mean	SD	Error rates	Mean	SD	Error rates	Mean	SD	Error Rates
Threatening Cat	684	241	0.04	671	220	0.06	687	227	0.09	691	234	0.08
Threatening Dog	717	231	0.07	698	200	0.07	722	212	0.1	700	205	0.11
Non-threatening Cat	699	236	0.05	718	234	0.06	692	215	0.07	686	212	0.08
Non-threatening Dog	693	214	0.05	712	218	0.05	717	234	0.11	716	228	0.1

Table 15.

Mean RTs (ms), standard deviations (SD), and error rates (proportions) in the neutral and no flanker conditions in the threat classification task in Experiment 6.

Target type	Flanker conditions					
	Neutral flankers			No flankers		
	Mean	SD	Error rates	Mean	SD	Error rates
Threatening Cat	663	200	0.07	655	207	0.07
Threatening Dog	699	218	0.11	707	224	0.10
Nonthreatening Cat	692	226	0.05	699	229	0.05
Nonthreatening Dog	709	250	0.07	687	205	0.06

Table 16.

Mean RTs (ms), Standard deviations (SD), and Error rates (proportion) from different flanker conditions in the animal classification task in Experiment 7.

Target type	Flanker conditions											
	Emotion congruent						Emotion incongruent					
	Animal congruent			Animal incongruent			Animal congruent			Animal incongruent		
	Mean	SD	Error rates	Mean	SD	Error rates	Mean	SD	Error rates	Mean	SD	Error Rates
Threatening Cat	784	221	0.06	792	222	0.12	771	215	0.08	794	228	0.09
Threatening Dog	792	200	0.07	794	216	0.07	798	227	0.09	788	212	0.07
Non-threatening Cat	706	212	0.02	730	222	0.03	722	196	0.02	724	190	0.03
Non-threatening Dog	738	198	0.06	736	188	0.05	778	225	0.05	764	195	0.07

Table 17.

Mean RTs (ms), Standard deviations (SD), and Error rates (proportion) of neutral and no flanker conditions in the animal classification task in Experiment 7.

Target type	Flanker conditions					
	Neutral flankers			No flankers		
	Mean	SD	Error rates	Mean	SD	Error rates
Threatening Cat	787	230	0.09	792	217	0.08
Threatening Dog	762	227	0.07	805	243	0.06
Non-threatening Cat	726	186	0.03	726	190	0.03
Non-threatening Dog	738	197	0.03	753	204	0.05

Table 18.

Mean RTs (ms), Standard deviations (SD), and Error rates (proportions) from different flanker conditions in the threat classification task in Experiment 7.

Target type	Flanker conditions											
	Emotion congruent						Emotion incongruent					
	Animal congruent			Animal incongruent			Animal congruent			Animal incongruent		
	Mean	SD	Error rates	Mean	SD	Error rates	Mean	SD	Error rates	Mean	SD	Error Rates
Threatening Cat	671	189	0.03	695	222	0.01	684	222	0.02	690	194	0.04
Threatening Dog	718	231	0.08	725	217	0.07	717	203	0.07	740	237	0.08
Non-threatening Cat	690	240	0.08	696	237	0.04	715	225	0.04	720	203	0.08
Non-threatening Dog	734	217	0.06	697	208	0.05	725	202	0.06	740	233	0.05

Table 19.

Mean RTs (ms), Standard deviations (SD), and Error rates (proportion) of neutral and no flanker conditions in the threat classification task in Experiment 7.

Target type	Flanker conditions					
	Neutral flankers			No flankers		
	Mean	SD	Error rates	Mean	SD	Error rates
Threatening Cat	681	220	0.02	706	216	0.02
Threatening Dog	715	240	0.08	735	247	0.09
Non-threatening Cat	719	243	0.05	728	215	0.06
Non-threatening Dog	728	230	0.05	744	250	0.06

Table 20.

Mean RTs (ms), Standard deviations (SD), and Error rates (proportion) from different flanker conditions in the animal classification task in Experiment 8.

Target type	Flanker conditions											
	Emotion congruent						Emotion incongruent					
	Animal congruent			Animal incongruent			Animal congruent			Animal incongruent		
	Mean	SD	Error rates	Mean	SD	Error rates	Mean	SD	Error rates	Mean	SD	Error Rates
Threatening Cat	691	96	0.08	716	92	0.13	724	127	0.10	717	89	0.13
Threatening Dog	777	187	0.06	788	139	0.08	759	154	0.09	751	126	0.09
Non-threatening Cat	669	75	0.06	667	96	0.08	678	133	0.03	672	91	0.06
Non-threatening Dog	682	123	0.07	703	104	0.08	684	112	0.04	689	96	0.05

Table 21

Mean RTs (ms), Standard deviations (SD), and Error rates (proportions) of neutral and no flanker conditions in the animal classification task in Experiment 8.

Target type	Flanker conditions					
	Neutral flankers			No flankers		
	Mean	SD	Error rates	Mean	SD	Error rates
Threatening Cat	702	108	0.11	714	121	0.11
Threatening Dog	728	116	0.06	775	170	0.06
Non-threatening Cat	695	117	0.06	683	107	0.05
Non-threatening Dog	646	98	0.04	683	123	0.06

Table 22.

Mean RTs (ms), Standard deviations (SD), and Error rates (proportions) from different flanker conditions in the threat classification task in Experiment 8.

Target type	Flanker conditions											
	Emotion congruent						Emotion incongruent					
	Animal congruent			Animal incongruent			Animal congruent			Animal incongruent		
	Mean	SD	Error rates	Mean	SD	Error rates	Mean	SD	Error rates	Mean	SD	Error Rates
Threatening Cat	693	178	0.05	678	162	0.04	676	147	0.05	688	129	0.07
Threatening Dog	689	146	0.09	690	151	0.09	707	143	0.11	738	193	0.10
Non-threatening Cat	697	137	0.05	678	118	0.07	689	139	0.06	693	133	0.05
Non-threatening Dog	698	122	0.08	682	126	0.10	712	146	0.06	758	253	0.07

Table 23.

Mean RTs (ms), Standard deviations (SD), and Error rates (proportion) of neutral and no flanker conditions in the threat classification task in Experiment 8.

Target type	Flanker conditions					
	Neutral flankers			No flankers		
	Mean	SD	Error rates	Mean	SD	Error rates
Threatening Cat	660	156	0.04	693	154	0.07
Threatening Dog	733	182	0.09	742	178	0.13
Non-threatening Cat	703	130	0.05	707	133	0.07
Non-threatening Dog	687	123	0.08	694	117	0.08

Table 24.

Mean RTs (ms), Standard deviations (SD), and Error rates (proportions) in Experiment 9a.

Target type	Location congruency	Flankers											
		Threatening Cat			Threatening Dog			Non-threatening Cat			Non-threatening Dog		
		Mean	SD	Error rates	Mean	SD	Error rates	Mean	SD	Error rates	Mean	SD	Error rates
Threatening Cat	Congruent	421	68	0.03	421	60	0.03	407	61	0.02	437	67	0.03
	Neutral	405	61	0.05	405	73	0.03	423	72	0.04	416	79	0.04
	Incongruent	430	67	0.04	430	69	0.05	437	64	0.04	439	63	0.05
Threatening Dog	Congruent	423	84	0.02	417	81	0.02	407	65	0.03	405	82	0.04
	Neutral	423	60	0.03	416	75	0.01	415	97	0.03	410	55	0.04
	Incongruent	430	63	0.03	443	101	0.04	450	88	0.02	428	71	0.04

Table 25.

Mean RTs (ms), Standard deviations (SD), and Error rates (proportions) in Experiment 9b.

Target type	Location congruency	Flankers											
		Threatening Cat			Threatening Dog			Non-threatening Cat			Non-threatening Dog		
		Mean	SD	Error rates	Mean	SD	Error rates	Mean	SD	Error rates	Mean	SD	Error rates
Non-threatening Cat	Congruent	413	87	0.02	406	86	0.03	417	97	0.01	414	89	0.02
	Neutral	409	80	0.01	399	81	0.02	413	86	0.02	409	73	0.02
	Incongruent	414	85	0.03	411	91	0.03	424	88	0.04	417	82	0.04
Non-threatening Dog	Congruent	420	97	0.004	410	83	0.02	414	101	0.02	401	76	0.02
	Neutral	405	70	0.02	410	88	0.03	400	80	0.03	406	82	0.03
	Incongruent	423	83	0.03	409	91	0.04	419	99	0.02	414	77	0.03

Table 26

Summary image statistics for images used in Experiment 10 and 11

Image	Non-threatening Cats		Threatening Cats		Non-threatening Dogs		Threatening Dogs		Birds		
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	
Property	Full color images										
Luminance	108	3.66	90	3.66	117	3.66	101	3.66	109	1.15	
Contrast	54.0	1.68	52.7	1.68	54.1	1.68	56.5	1.68	38	0.52	
	Grayscale images										
Luminance	108	3.67	90	3.67	117	3.67	101	3.67	109	1.15	
Contrast	53.4	1.65	52.8	1.65	54.2	1.65	56.5	1.65	38	0.52	

Table 27.

Mean reaction times (RTs), standard errors (SE), and mean percentage error rates (%E) for the various conditions of interest in the detection task in Experiment 10.

Trial type	Display set size								
	3			6			9		
	Mean	SE	%E	Mean	SE	%E	Mean	SE	%E
Threatening cat	851	21	3.6	968	28	2.9	1056	25	4.2
Threatening dog	869	30	4.4	975	23	4.4	1141	26	5.7
Non-threatening cat	1020	31	1.2	1129	14	9.6	1297	39	14.8
Non-threatening dog	905	24	8.1	1104	27	7.3	1279	37	12.2
Absent	1000	13	1.3	1512	33	1.3	1852	56	1.8

Table 28.

Mean reaction times (RTs), standard errors (SE), and mean percentage error rates (%E) for the various conditions of interest in the classification task in Experiment 10.

Trial type	Display set size								
	3			6			9		
	Mean	SE	%E	Mean	SE	%E	Mean	SE	%E
Threatening cat	1043	23	9.6	1202	24	9.4	1332	32	9.1
Threatening dog	1148	22	6.8	1339	26	7.8	1477	41	7.3
Non-threatening cat	1059	26	2.1	1346	28	2.9	1608	42	2.9
Non-threatening dog	1127	26	3.4	1297	32	2.9	1500	34	5.7

Table 29.

Mean reaction times (RTs), standard errors (SE), and mean percentage error rates (%E) for the various conditions of interest in the detection task in Experiment 11.

Trial type	Display set size								
	3			6			9		
	Mean	SE	%E	Mean	SE	%E	Mean	SE	%E
Threatening cat	926	23	2.1	1030	23	2.1	1119	23	6.0
Threatening dog	896	28	4.4	1091	25	2.6	1155	22	6.3
Non-threatening cat	980	28	7.3	1179	27	8.3	1346	35	11.5
Non-threatening dog	956	31	7.8	1185	32	6.0	1316	29	8.3
Absent	1070	16	1.6	1525	31	1.8	1887	63	1.1

Table 30.

Mean reaction times (RTs), standard errors (SE), and mean percentage error rates (%E) for the various conditions of interest in the classification task in Experiment 11.

Trial type	Display set size								
	3			6			9		
	Mean	SE	%E	Mean	SE	%E	Mean	SE	%E
Threatening cat	1119	32	6.3	1268	28	3.1	1350	28	3.4
Threatening dog	1104	17	2.9	1331	40	3.4	1439	30	3.1
Non-threatening cat	1082	28	1.8	1395	37	1.3	1627	38	1.8
Non-threatening dog	1119	25	2.3	1336	31	2.6	1523	40	2.6

Table 31.

Mean reaction times (RTs), standard errors (SE), and mean percentage error rates (%E) for the various conditions of interest in the animal classification task in Experiment 12.

Trial type	Image format					
	Full color			Grey scale		
	Mean	SE	%E	Mean	SE	%E
Threatening cat	834	24	15.0	841	27	14.7
Threatening dog	772	22	6.2	802	23	7.5
Non-threatening cat	799	20	4.7	819	22	6.1
Non-threatening dog	729	20	4.1	741	19	3.7

Table 32.

Mean reaction times (RTs), standard errors (SE), and mean percentage error rates (%E) for the various conditions of interest in the threat classification task in Experiment 12.

Trial type	Image format					
	Full color			Grey scale		
	Mean	SE	%E	Mean	SE	%E
Threatening cat	731	21	5.2	774	23	5.6
Threatening dog	771	22	10.2	784	26	10.2
Non-threatening cat	708	26	4.4	731	22	3.7
Non-threatening dog	700	24	6.6	723	23	6.3

Table 33.

Mean reaction times (RTs), standard errors (SE), and mean percentage error rates (%E) for the various conditions of interest in the detection task in Experiment 13.

Trial type	Display set size								
	3			6			9		
	Mean	SE	%E	Mean	SE	%E	Mean	SE	%E
Threatening cat	773	30	3.6	937	24	5.7	1045	20	6.3
Threatening dog	837	17	8.3	950	21	7.0	1083	26	8.1
Non-threatening cat	804	17	6.0	968	22	5.5	1037	30	9.4
Non-threatening dog	875	15	5.2	1009	23	6.5	1071	23	9.9
Absent	922	12	2.1	1330	34	1.1	1583	41	1.9

Table 34.

Mean reaction times (RTs), standard errors (SE), and mean percentage error rates (%E) for the various conditions of interest in the classification task in Experiment 13.

Trial type	Display set size								
	3			6			9		
	Mean	SE	%E	Mean	SE	%E	Mean	SE	%E
Threatening cat	1030	14	8.6	1206	26	8.6	1315	31	7.8
Threatening dog	1127	22	8.1	1325	29	5.2	1407	31	8.3
Non-threatening cat	945	21	2.6	1112	25	1.8	1279	27	3.9
Non-threatening dog	1093	26	3.6	1242	22	2.6	1382	27	2.9

Table 35.

Mean reaction times (RTs), standard errors (SE), and mean percentage error rates (%E) for the various conditions of interest in the animal classification task in Experiment 14.

Target type	Mean	SE	%E
Threatening cat	753	29	11.4
Threatening dog	775	30	9.9
Non-threatening cat	676	24	4.5
Non-threatening dog	733	23	4.3

Table 36.

Mean reaction times (RTs), standard errors (SE), and mean percentage error rates (%E) for the various conditions of interest in the threat classification task in Experiment 14.

Target type	Mean	SE	%E
Threatening cat	664	16	3.5
Threatening dog	702	19	5.7
Non-threatening cat	679	17	1.6
Non-threatening dog	750	19	7.9

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