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Cognitive and Psychophysiological Responses to Threat Stimuli: The Effect of Perceived Proximity

by

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ABSTRACT

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COGNITIVE AND PSYCHOPHYSIOLOGICAL RESPONSES TO THREAT STIMULI: THE EFFECT OF PERCEIVED PROXIMITY

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Various theoretical models (e.g. Lang et al., 1997; McNaughton & Gray, 2000) are based largely on animal research, including the work of animal behaviourists (e.g. Blanchard & Blanchard, 1988; Fanselow, 1994) who observe how animals react to different kinds of threat stimuli. Other models (e.g. Williams et al., 1997; Mogg & Bradley, 1998), on the other hand, are based on the study of anxiety disorders in humans from a clinical and cognitive perspective. However, both types of model make predictions as to how an individual will respond to threatening stimuli. The issue of the perceived proximity of a threat is of particular importance in the models based on animal research in determining the type of defence behaviour a threat elicits. These models suggest that a distal threat elicits a vigilant set of behaviours, which allow for the assessment and processing of the threat. However, in response to a proximal threat these behaviours give way to active defence behaviours, such as fight-or-flight. Cognitive models also provide a basis for generating predictions as to how attentional allocation will alter as a threat increases in perceived proximity. These models suggest that the bias in initial orienting of an anxious individual will intensify as a threat cue becomes more aversive, for example, as it increases in proximity. This initial allocation of attention may then be followed by avoidance.

In a series of six studies, this thesis examines the effect of the perceived proximity of a threat on cognitive and psychophysiological responses. Study 1 used a visual probe task to assess initial attentional allocation in high and low spider-fearful participants to pictures of distally and proximally perceived spiders and rabbits. However, the results did not show a significant interaction effect of fear group and stimulus proximity on attentional bias. Study 2 involved a physiological recording task measuring startle eye blink and skin conductance responses (SCR) followed by a visual probe task, using similar stimuli and participants. The results showed that the proximal spider pictures elicited a potentiated startle response in the high fear group. This group also showed greater SCRs to the spider pictures in general. Study 3 involved a hybrid task that allowed for the concurrent assessment of attentional measures and physiological responses. Although the high fear group showed potentiated startle and SCRs whilst viewing the spider pictures, there was no difference in their psychophysiological responses between the two perceived proximity conditions. The eye movement measures showed that the high fear group was more likely than the low fear group to direct their gaze towards spiders; however this bias was not affected by the proximity manipulation. Study 4 used the same hybrid task, but involved a greater size ratio between the proximal and distal stimuli. The startle probe results replicated the finding of Study 2, with the proximal spiders eliciting a potentiated startle response in the high fear group. However, the other measures did not differentiate between the fear groups. Study 5 looked at behavioural action tendencies using an Affective Simon Task. Participants in the high fear group were relatively faster to avoid and slower to approach proximal spiders compared to the low fear group. Study 6 assessed eye movement measures. The high fear group demonstrated faster initial orienting towards the proximal spiders, followed by avoidance, as reflected by the duration of gaze.

The results of these studies suggest that the psychophysiological and attentional responses elicited by proximal and distal threat are indeed different, as predicted by the various models discussed. Distal threat elicits increased SCRs in fearful participants, but no reliable potentiated startle response or behavioural tendencies of avoidance. Proximal threat, on the other had, elicits increased SCRs and a potentiated startle response (in 2 out of 3 studies), faster initial orienting with subsequent avoidance, and the behavioural tendencies of avoidance in fearful participants. These results provide some support for predictions from both the cognitive models of anxiety and the models based on animal behaviours.

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Chapter One: Introduction

Introduction

The cognitive, physiological and behavioural responses to threatening stimuli have been described by various theoretical models based on work in many different fields of psychology. First, studies have been done examining animal's responses to threat (e.g. Blanchard & Blanchard, 1988; Fanselow, 1994), and this has led to the development of models that describe such behaviour in humans (e.g. Lang, Bradley & Cuthbert, 1997; McNaughton & Gray, 2000). Some evidence in support of these models have come from psychophysiological studies examining measures such as the startle reflex and skin conductance responses (SCR). Secondly, work has also been done in cognitive and clinical psychology looking at emotional disorders in humans. This has led to the development of models which describe attentional responses to threat with particular reference to anxiety (e.g. Mathews & Mackintosh, 1998; Mogg & Bradley, 1998; Öhman, 1996; Williams, Watts, MacLeod & Mathews, 1997). Research into how attention is initially oriented and subsequently maintained, using methods such as the Stroop and visual probe tasks, eye movement monitoring and masked stimulus presentation, have supported some of the predictions of these models. Finally, research concerning implicit measures of valence has led to the development of a paradigm which can be used to assess behavioural response tendencies elicited by threatening stimuli (De Houwer, Crombez, Baeyens & Eelen, 2001).

Therefore, there is a plethora of theoretical models and research concerning the different cognitive, physiological and behavioural responses to threat stimuli. The aims of this thesis are to test the predictions from these various models in an attempt to examine what happens to the physiological, attentional and behavioural responses elicited by threatening stimuli of increasing proximity. The models mentioned above provide a basis for making predictions concerning the effect this manipulation will have on the responses observed. This will be done by examining the effect of a threat's perceived proximity on the physiological and attentional responses observed in, and on behavioural action tendencies displayed by, high and low spider-fearful participants.

In this *Introduction* the models mentioned briefly above will be expanded upon, together with a review of the most pertinent experimental research. The models have been split up into several broad categories based, for the most part, on the type of research they involve. First, models with a background in the study of animal behaviour will be discussed. These include early work done by animal behaviourists (e.g. Blanchard & Blanchard, 1988; Fanselow, 1994) and models based, at least in part, upon this research (e.g. Lang, Bradley & Cuthbert, 1997; McNaughton & Gray, 2000). Relevant experimental studies done in this area will then be reviewed with particular emphasis on startle and skin conductance responses to threat stimuli. Secondly, models with a background in clinical and cognitive psychology will be discussed (e.g. Mathews & Mackintosh, 1998; Mogg & Bradley, 1998; Öhman, 1996; Williams et al., 1997) together with a review of the most relevant experimental literature using Stroop, visual probe, eye movement, and masking methodologies. Finally, there will be a section discussing implicit valence evaluations and the methodologies involved which may be used to assess behavioural action tendencies in response to threat. This chapter will conclude with a review of the aims and objectives of the thesis.

Theoretical Models Based on Animal Research

Research into the behaviour patterns observed in lower mammals, such as rats and mice, can have important implications for the understanding of human behaviour. Of particular interest are the behaviours observed in response to threat. Similar patterns of behaviours have been observed across several mammalian species, such as rats, mice and cats (Blanchard & Blanchard, 1988), leading to the conclusion that attack and defence behaviours are organised according to specific functions which are universal. Such work has led to the proposal of a defence system split into two levels, each associated with a distinct set of behaviours, which are activated by different types of threatening stimuli (e.g. Blanchard & Blanchard, 1988; Blanchard, Griebel, Henrie, & Blanchard, 1997).

Blanchard and Blanchard (1988) characterised the anti-predator defence patterns of behaviour observed in rats and concluded that they are generalisable across species. These behaviours encompass flight, defensive threat and attack behaviours, all of which are prompted by encounters with an actual threat. They observed that when faced with an actual threat, such as a predator, flight is the dominant response when escape is possible. However, if escape routes are blocked, freezing is the primary defence. If the approaching predator comes too close (e.g. about 1m. from a rat), freezing is followed by defensive threat (vocalisation and showing teeth) and finally, attack (at a distance of about 0.5 m from the rat). The Blanchard's link these defence behaviours to neural mechanisms in the amygdala and midbrain periaqueductal gray (PAG).

However, these behaviours are only effective when a specific threat stimulus is present, as they involve being able to avoid the specific threat or attack it, if necessary. However, if, for example, only odours or traces of potential threat are present, a risk assessment pattern of behaviour is observed. The Blanchards (1988) characterise risk assessment as the behaviours which allow an animal to both assess and avoid the potential threat, with the animal continually striving for a "best fit between the opposing demands of risk avoidance and risk assessment" (Blanchard & Blanchard, 1988, pg. 47). In response to a potential threat, an animal flees or hides when an escape route or a hiding place is available. These behaviours avoid the potential threat, but do not allow any information to be gathered about its nature. So, after some time with no further indication of threat, the animal re-enters the area to explore. This starts with brief forays followed by retreat; with the time spent in the area gradually increasing provided there are no further signs of danger. If escape is not possible upon encountering evidence of a potential threat, the animal freezes, either with complete immobility, leading to high avoidance but low assessment of threat, or with scanning motions, allowing for some assessment of the potential threat. If there is no further indication of danger, this freezing gives way to more active exploration, and finally to a return to normal behaviours. The Blanchards link these risk assessment behaviours to a defence inhibitory system in the septal area of the hippocampal system.

Therefore, there appears to be a distinction between the defence behaviours observed in response to an actual predator and the risk assessment behaviours observed in response to a potential predator. This distinction is further supported by work into the effect of panicolytic and anxiolytic drugs on these behaviours. Blanchard, Yudko, Rodgers and Blanchard (1993) used semi-natural settings to examine these various defence behaviours. They used the fear/defence test battery to measure an animal's behaviour in response to an actual approaching predator and the anxiety/defence test battery to measure reactions to potential threats. They found that the risk assessment behaviours, observed in the anxiety/defence test battery, were affected when the animals were given anxiolytic drugs, which are known to be effective in reducing anxiety. However, the fight-or-flight behaviours, observed in the fear/defence test battery, remained unaffected. Similarly, Blanchard Griebel, Henrie and Blanchard (1997) examined behaviour in rats and mice after having been injected with anxiolytic or panicolytic agents. They found that anxiolytic drugs led to a reduction in some of the behaviours observed during risk assessment. In contrast, panicolytic drugs in repeated doses, such as alprazolam, imipramine and fluoxetine, all of which are effective in alleviating panic, reduced flight - a defence behaviour. Imipramine and fluoxetine were also found to change other defence behaviours, for example decreasing defensive attack, but not changing the risk assessment behaviours elicited in response to an approaching predator. Furthermore, yohimbine, effective in eliciting panic, was found to potentiate the defence behaviours of avoidance and escape behaviour, whilst reducing the risk assessment behaviour of freezing (Blanchard et al., 1997). Finally, Blanchard, Griebel and Blanchard (2001) found that the flight responses, exhibited in mice who were subjected to the mouse fear/defence test battery, were increased when mice were given panic provoking drugs, such as yohimbine or cocaine. However, this flight response was reduced when the mice were given antipanic treatments such as alpraxolam or imipramine, and remained unchanged when they were given ineffective panic treatments such as buspirone or chlordiazepoxide. These results suggest that the defence and risk assessment behaviours observed in mammals may be generalisable to human emotional responses and emotional disorders.

Other work has led to a distinction in behaviours observed in animals during the approach of a threatening stimulus. Fanselow (1994) developed work initially done by

Fanselow and Lester (1988), who put forward the notion of a response-selection rule. According to this view, it is the likelihood of fatal attack by a predator, as perceived by the prey, which determines the type of behaviour displayed. This perception is seen in terms of imminence, which encompasses factors such as the spatial distance from the threat and the temporal likelihood of actual physical contact with the threat. In this view, defensive behaviour is divided into three stages:

1. Pre-encounter stage: which occurs in situations where a threat/predator may be encountered, but when none is detected at present. So, normal foraging behaviours are observed, but these are reorganised to enable the animal to act appropriately if a threat is encountered.
2. Post-encounter stage: which occurs upon detection of a distant predator. Freezing is observed and normal behaviours inhibited. This is done in order to reduce the chance of detection by the predator and to allow the animal to assess the risk of the situation. Fanselow (1994) relates these behaviours to the amygdala and ventral periaqueductal gray.
3. Circa-strike stage: occurs when physical contact with predator is actually occurring or is perceived to be inevitable. Defensive fighting and threat displays are observed along with flight (escape) if possible. Fanselow (1994) relates these behaviours to the dorsal periaqueductal gray and the superior colliculus.

Across these three stages, there is a shift from non-specific threat vigilance in the pre-encounter stage, to post-encounter freezing and orienting towards the threat, to the circa-strike stage where the animal is beyond vigilance and is engaged in active defence. This model is consistent with the distinction between different types of defensive behaviour – risk assessment versus active defence. Where the Blanchards (1988) based their distinction on actual versus potential predators, Fanselow (1994) based his distinction on the distance the threat is from the animal.

Gray and McNaughton (1995) proposed a model of the neuropsychological mechanisms involved in anxiety. Like the Blanchards (1988) and Fanselow (1994), they also proposed a distinction between the various behaviours observed in responses the threatening stimuli. In their hierarchical system, they see fight and/or flight behaviour as resulting from a proximal predator/threat, which they related to the periaqueductal gray. Directed escape is seen as resulting from a distant predator, which allows more time for analysis of the situation, and is related to the medial hypothalamus. Next, there is active avoidance which results from the detection of a potential threat which need not be approached, and this is linked to the amygdala. Finally, there are the behavioural inhibition and risk assessment behaviours, which occur in response to a potential threat that must be approached. Following on from the conclusions of Blanchard & Blanchard (1988), they make a special case for this behavioural inhibition and risk assessment system. This is seen as anxiety, and is related to the septum, hippocampus and the amygdala. Gray and McNaughton (1995) see the septo-hippocampal system (SHS) as the main structure in the mediation of anxiety in humans. Similar results are seen with anxiolytic drug administration, which reduce anxiety, as when lesions are made to the SHS.

McNaughton and Gray (2000) expanded upon this model. Again citing the risk assessment category of defence behaviours put forward by the Blanchards (1988), they viewed anxiety as "a conflict between two incompatible goals – in the simple defensive case, a conflict between...obtaining food for yourself and not becoming food for someone else" (pg. 165). The SHS is seen as a comparator of inputs; it receives and codes inputs about the state of the world and makes predictions about expected events and the upcoming steps in current behavioural motor programme with which the organism is engaged. Activation of the hippocampus is seen as rumination on the current situation and the motor programme currently instigated. However, when there is a mismatch between observed and expected events, for example signals of punishment, innate fear stimuli, novel stimuli or signals of non-reward, the comparator produces output which causes the current motor programme to execute future steps more slowly and carefully, or replaces it altogether with attempts to resolve the problem. Where conflict results from the activation of both approach and avoidance tendencies, for example, as was stated above, a potential threat that needs to be approached, the defence systems are activated. McNaughton and Gray (2000) see anxiety as controlling behaviours which allow an animal to enter a dangerous situation. So, in the case of an approach/avoidance conflict anxiety is induced, and results from activation of both the amygdala and the septo-hippocampal system. However, when there is no conflict, for example when only avoidance is activated, amygdala activation without SHS involvement results in the activation of defence behaviours which allow the animal to leave a dangerous situation. This is seen by McNaughton and Gray (2000) as fear.

It may be important to note that the neural bases described by McNaughton and Gray (2000) are not the same as those highlighted by other researchers. For example, as was discussed above, Fanselow (1994) cited the amygdala and ventral periaqueductal gray as being the brain areas involved with the sensory assessment of a distant threat and the dorsal periaqueductal gray and the superior colliculus as being involved with active defence (see also Bouton, Mineka & Barlow, 2001, discussed below). Furthermore, a great deal of evidence supports the idea of the amygdala and related brain structures as playing a major role in fear and defensive behaviours (e.g. LeDoux, 1996; Rosen & Schulkin, 1998).

Nevertheless, there is a body of evidence, albeit with slight differences in neural bases, suggesting that defensive behaviours are not merely a single category controlled by a single neural system. Rather, there appears to be at least two distinct classes of behaviour which can be prompted by threatening stimuli. Anxiety or risk assessment is instigated by the detection of a distant or potential predator and involves freezing and scanning behaviours allowing the animal to both assess and avoid the threat potential. On the other hand, fear (defensive behaviours, circa-strike, panic) is elicited by a close encounter with an actual predator and involves escape or attack and threatening behaviours.

The work of the animal behaviourists (e.g. Blanchard & Blanchard, 1988; Fanselow, 1994) has had an impact on how psychologists view anxiety and fear reactions in humans. Barlow (1988; 2002) proposed a conditioning theory of clinical anxiety disorders which uses the distinction between panic and anxiety. His conception of panic is that of unconditioned fear, involving the fight-or-flight response, which occurs at the wrong time. The anxiety comes as the patient focuses on the potential of the next attack, and becomes extremely vigilant for any symptoms which may signal its arrival. Similarly, Bouton, Mineka and Barlow (2001) defined panic as “a subjective sense of extreme fear or impending doom accompanied by a massive autonomic surge and strong flight-or-fight behavioural action tendencies” (pg.9) and anxiety as “an apprehensive anticipation of future danger, often accompanied by somatic symptoms of tension or feelings of dysphoria” (pg.9). This distinction between panic and anxiety, and the responses that are associated with them, mirrors the distinction made by the animal behaviourists cited above (e.g. Blanchard & Blanchard, 1988; Fanselow, 1994). With fear or panic resulting from an actual life-threatening event, as perceived by the individual, and anxiety resulting from uncertainty and the anticipation of an aversive event/stimulus. It is also interesting to note that Bouton et al. (2001) linked the behaviours associated with anxiety to the brain areas cited by Fanselow (1994) as being involved with the sensory assessment of a distant threat, namely the central amygdala and ventral periaqueductal gray. They also linked the behaviours involved in panic to the brain areas cited by Fanselow (1994) as being involved with active defence, namely the dorsal periaqueductal gray and the superior colliculus.

Lang, Bradley and Cuthbert (1997) apply this fear/anxiety distinction directly to human behaviour in their Defence Cascade model. This model makes specific predictions concerning the physiological responses elicited in humans as a threat increases in arousal, which is seen as being analogous to predator imminence. However, before this model is described, some theoretical background is needed.

This area of research looks at human reactions to emotional stimuli. In the views of Lang et al. (1997), emotions are seen as "action dispositions" which "can prompt states of heightened, highly focused attention – behaviourally static, but reflecting central activation and preparation for action" (pg. 99). Therefore, emotions can lead to behavioural sequences, such as patterns of approach or avoidance, physiological changes mediated by the somatic and autonomic nervous system, and responses in expressive and evaluative language. Lang et al. (1997) propose that two motivational systems exist in the brain, an appetitive system and an aversive/defence system. These systems are activated depending upon the valence of a stimulus, with the appetitive system motivationally relevant for positive stimuli and the aversive/defence system relevant for unpleasant and/or threatening stimuli. The strength of activation of either system is dependent on the arousal value of the stimulus, with highly arousing stimuli prompting greater activation.

Work using the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1995) has demonstrated this division. Responses to the different IAPS pictures have resulted in a boomerang-shaped distribution of the pictures in two-dimensional affective space. Two arms extend from a neutral non-affective base to (1) a high-arousal pleasant quadrant and (2) a high-arousal unpleasant quadrant. This supports the view of two systems, of appetitive and aversive valence, that each varies in strength along a dimension of arousal (Lang et al., 1997; Lang, Bradley, & Cuthbert, 1998). Further support comes from a study by Lang, Greenwald, Bradley and Hamm (1993). This study looked at subjective ratings of valence and arousal, viewing time, reports of interest, heart rate, skin conductance responses (SCR) and corrugator and zygomatic muscular responses (the facial muscles involved in frowning and smiling respectively) to forty-two IAPS pictures. A factor analysis of the data resulted in a two-factor solution. Valence ratings, heart rate, and corrugator (negatively) and zygomatic EMG loaded onto the valence factor, and arousal and interest ratings, viewing time and SCR loaded onto the arousal factor.

Within the aversive/defence system, activated by stimuli of a negative valence, the autonomic and somatic patterns of behaviour can be organized into two classes (Lang et al., 1997; Lang, Davis, & Öhman, 2000):

1. Defensive immobility: which includes behaviours such as freezing, bradycardia and hyper-attentiveness. Such behaviours indicate that the organism is passive, but is primed to respond actively to further stimulation.

2. Defensive action: which includes behaviours such as flight or flight which are direct responses to imminent attack.

This distinction (Lang et al., 2000) parallels that made by the animal behaviourists. In fact, Lang, Davis and Öhman (2000) define fear as "a reaction to an explicit threatening stimulus with escape or avoidance being the outcome of increased threat proximity" (pg. 144) and anxiety as a "generalised state of distress, more long lasting, prompted by less explicit or more generalised cue, involving physiological arousal often without organized functional behaviour" (pg. 144).

From this theoretical background, and citing the three classes of behaviour defined by Fanselow (1994), Lang et al. (1997) propose the defence cascade model. In this model, the emotional intensity of a threat stimulus is seen as being analogous to predator imminence in animal behaviour research (Lang et al., 2000). The model therefore predicts the amplitudes of various measures of orienting and defence elicited in humans by a threatening stimulus increasing in arousal or proximity, see Figure 1.1 below.

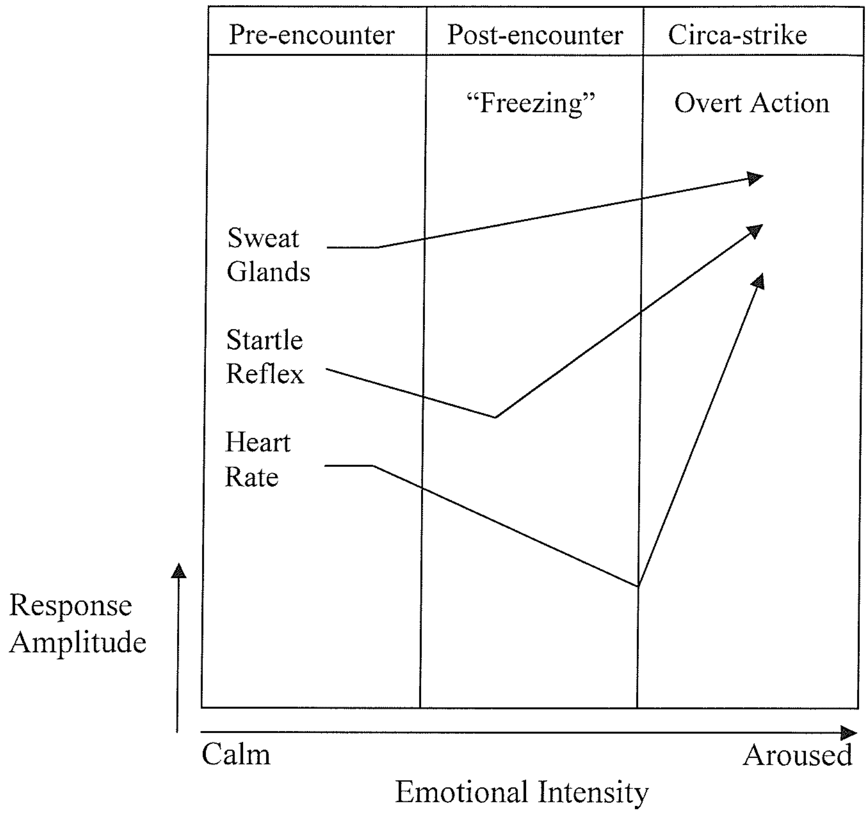

Figure 1.1: The defence cascade model, adapted from Lang et al. (1997).

At the post-encounter stage (elicited, for example, by very mild threat), perceptual processing of the stimulus occurs. At this stage defensive activation is still low. Here the classical physiological indices of orienting can be observed; cardiac deceleration, moderate skin conductance responses (SCR) and a relative inhibition of the startle reflex. These responses are all signs of sensory intake and occur as a result of the initial detection and processing of an aversive stimulus – "reactions to the startle probe are predominantly inhibitory … this is consistent with the hypothesis of attentional resource allocation" (Lang et al., 1997, pg. 128). However, with greater activation this oriented attention gives way to activation for active defence behaviours. This is signalled by greater SCR and a potentiation of the startle response, which is seen as a premature defence reflex and which reflects an increase in the probability of overt defensive action (Bradley, Cuthbert, & Lang, 1999; Lang et al.,

1997) – “clear evidence that the organism has changed to a defensive posture is first seen in the probe reflex response” (Lang et al., 1997, pg. 128). The change in behaviour from orienting to defence is achieved by increasing activation of the subcortical aversive motivation system. It is reflected cortically by a “cognitive shift from a passive attention set to the processing of action” (1997, pg. 128). So, the cognitive processes involved in defence are seen by Lang et al. (1997) as a “staged transition from attention into action – from sensory processes to efferent procedures that cope directly with threat stimuli” (pg. 128).

Therefore, the defence cascade model (Lang et al., 1997) makes specific predictions as to the physiological and behavioural responses elicited in humans as threat stimuli increase in adversity/arousal and proximity. These predictions are similar to those made by other models discussed in this section. The defence cascade model (Lang et al., 1997) is based on the work done by Blanchard and Blanchard (1988) and Fanselow (1994). Therefore, it uses the distinctions they make between a risk assessment phase in which a potential and distant threat is processed and an active defence stage in which the individual escapes from, or fights, with an actual and proximal predator. McNaughton and Gray (2000) also suggest that differences in responses occur depending on the type of threat stimulus. They too highlight the difference between a behavioural inhibition and risk assessment stage involved in anxiety and the fight-or-flight response involved in fear. This thesis will endeavour to explore these predictions by examining the effect of the perceived proximity of a threat on the cognitive, physiological and behavioural responses in humans. The models discussed above (e.g. Fanselow, 1994; McNaughton & Gray, 2000; Lang et al., 1997) predict that in response to a distally perceived threat, an individual will display increased attentional processing (for example, in terms of an attentional bias or enhanced eye movements for the distal threat) but no heightened physiological or behavioural responses (for example, no potentiated startle response or behavioural tendencies of avoidance). However, a proximally perceived threat would be expected to elicit a loss of attentional processing (therefore no attentional bias or enhanced eye movements) in favour of active defensive behaviours, both physiological (i.e. a potentiated startle and skin conductance response) and behavioural (i.e. behavioural action tendencies of avoidance).

There have been numerous studies conducted which partially examine these predictions using physiological paradigms. Some of the most relevant studies will be reviewed in the following section.

Physiological responses to Threat – Empirical Evidence

The startle reflex, an important part of the defence cascade model, is seen as a primitive defensive reflex which protects the animal, for example avoiding organ injury (as in the eye blink component) and acting as a behavioural interrupt which clears processors to allow them to deal with potential threat (Lang et al., 1997). In humans, sudden eyelid closure is one of the most reliable components of behavioural cascade which makes up the startle response (Lang et al., 1998). The acoustic eye blink reflex usually is the result of orbicularis oculi muscle activity about 30-50ms after the eliciting acoustic startle stimulus (Berg & Balaban, 1999). Neurobiological research has indicated that the amygdala plays a critical role in the fear-potentiation of the startle reflex in humans (Grillon, 2002). The fear-potentiated startle reflex refers to the observation that the magnitude of the startle reflex can be modulated by stimuli of different valence (Vrana, Spence & Lang, 1988, see below). Measures of skin conductance responses (SCRs) are also an important part of the Defence Cascade model. In humans, SCRs are measured using electrodes placed on the distal phalanges of the non-dominant hand. The following studies provide a review of human physiological responses to different types of threatening stimuli. This is by no means exhaustive, but rather will attempt to highlight the major findings concerning physiological responses to threat stimuli.

Lang, Bradley and Cuthbert (1990) observed that the startle reflex varies systematically with the valence of an organism's emotional state and propose a motivational hypothesis of startle modulation. SCRs on the other hand appear to vary with the arousal value of that emotional state (Bradley, 2000; Lang et al., 1993). In one of the earliest studies using the startle probe paradigm to measure emotion, Vrana et al. (1988) had participants view pictures of positive, negative and neutral stimuli for 6s. Acoustic startle probes were presented binaurally and comprised a 50ms burst of 95dB white noise with a nearly instantaneous rise time. These occurred unpredictably during the course of slide exposure and between slides. They found that the magnitude of acoustic probes varied linearly with the judged emotional valence of the pictorial slide foreground – blink magnitude increased significantly from pleasant to neutral to unpleasant slides. Only reports of emotional valence followed the pattern of startle reflex magnitudes; self-reports of interest and arousal, and measures of SCR and viewing time did not. SCRs were observed to vary with reports of the emotional arousal value of the pictures. There was no difference in the SCRs to pleasant and unpleasant pictures, both of which were rated as highly arousing, whereas the SCRs to these differed from those elicited by less arousing neutral pictures. Similar results were found by Bradley, Cuthbert and Lang (1990) who used both auditory and visual startle probes; auditory probes consisted of a sudden loud burst of white noise whereas visual probes were strobe bursts. They found that, although blink magnitudes were somewhat larger for auditory than for visual probes, both showed the same linear distribution over the valence categories – an increase from positive through neutral to negatively valenced slides. Therefore, pleasant foregrounds prompt an inhibition, and unpleasant a potentiation, of the startle eye blink response, regardless of startle probe modality. These results provide support for Lang et al.'s (1990) motivational hypothesis for startle modulation.

Hamm, Greenwald, Bradley and Lang (1993) conducted a study using a conditioning paradigm to examine the startle probe response to fear conditioned stimuli. In line with predictions, they found that the startle blink reflex was markedly potentiated to acoustic probes which occurred during pictures (both pleasant and unpleasant) which had previously been paired with electric shocks. These blink magnitudes were significantly larger than blink magnitudes elicited by probes during pictures which had not been paired with an electric shock, and with probes occurring during the inter-trial interval. They also found that the startle probe potentiation varied linearly with the *a priori* affective valence of the pictures. That is, the increase in startle eye blink response found when comparing responses before and after conditioning was significantly less for unpleasant pictures than for pleasant pictures. This study provides further evidence that the startle probe reflex is a defensive response to an independent event (the acoustic probe) augmented by the motivational state of the individual as prompted by emotional stimuli. If an individual is in an aversive motivational state, which is induced either by the presence of an unpleasant stimulus or an association between the stimulus and an unpleasant event, the occurrence of another aversive event (e.g. an acoustic startle) will elicit a larger defensive response – a potentiated startle. If however the individual is in an appetitive motivational state, which is induced by a pleasant stimulus or one that does not have an unpleasant association, the occurrence of an aversive event will lead to a much less strong defensive response – an inhibited startle. SCR, on the other hand, was not found to be associated with valence, but rather with arousal. Participants viewing pictures rated high in arousal (e.g. erotica and mutilated bodies) showed only a small change in SCRs before and after conditioning, as their initial SCR to these stimuli was already high. However, subjects viewing neutral pictures showed significant changes in SCR before and after conditioning, when the pairing of certain neutral pictures with an electric shock increased their emotional arousal value, thereby resulting in a greater change when comparing responses pre- and post- conditioning.

Yartz and Hawk (2002) examined whether the valence modulation of the startle reflex occurred only for fear-relevant stimuli. They measured the startle eye blink response to acoustic probes whilst participants viewed both fear-relevant and disgust-relevant IAPS pictures. They found that startle blink magnitude was potentiated in participants during the viewing of both fear- and disgust-relevant stimuli, compared to pleasant stimuli. This result supports Lang et al.'s (1990) view that valence in general modulates the startle response; with the viewing of negative fear/disgust/threat stimuli leading to a potentiation in the startle eye blink response to an auditory startle probe.

Sabatinelli, Bradley and Lang (2001) also found the normal pattern startle modulation to the stimuli once they were presented; an inhibition of the response for pleasant pictures and a potentiation in the response for negative pictures. Miller, Patrick and Levenston (2002) examined whether the acoustic startle reflex could be modulated during emotional imagery. They found that the startle response was greater during aversive imagery than pleasant imagery. The fact that this valence modulation is observed during imagined stimuli shows the durability of the valence modulated startle effect. Cuthbert, Schupp, Bradley, McManis and Lang (1998) found the valence modulation of the occurred even when participants were instructed to either directly attend to or ignore the startle probe. This suggests that the affective modulation is not affected by the direction of attention. Hawk and Cook (2000) found that valence modulation was independent of another phenomenon often studied in physiological tasks called prepulse inhibition. Prepulse inhibition occurs when a lead stimulus is presented within a couple of hundred milliseconds before the startle stimulus and subsequently causes an inhibition in the startle response to the startle stimulus (Blumenthal, 1999). However, Hawk and Cook (2000) were able to measure both effects within the same paradigm, and found that the degree to which individuals showed prepulse inhibition was not related to their tendency to show valence modulation in the startle reflex. Therefore, the modulation of the startle reflex observed in response to stimuli of different valences is occurring independently of the more basic response of PPI. Finally, Bradley, Lang and Cuthbert (1993) found that, although the magnitude of the startle response showed a progressive reduction in amplitude with repeated elicitation, the valence modulation showed no habituation over time, nor did it diminish with picture repetition. All these studies indicated that the startle response is a sensitive and reliable measure of the valence of affective stimuli.

Many studies have examined the startle reflex in people with specific phobias. As phobic fear is characterised by extreme withdrawal and avoidance dispositions, phobia-relevant stimuli are expected to elicit a potentiated startle response (Hamm, Cuthbert, Globisch & Vaitl, 1997). For example, both de Jong, Merckelbach and Arntz (1991) and de Jong, Arntz and Merckelbach (1993) examined the startle eye blink response to acoustic probes elicited in phobic women during a spider behavioural approach test (BAT), both before and after a session of exposure treatment. Both studies found that the startle probe response magnitudes during the spider BAT were greater than during a BAT with a food item (used in both studies) or a piece of wood (used only by de Jong et al., 1993). After treatment, the participants had significantly lower scores on the Spider Phobia Questionnaire (SPQ; Klorman, Weerts, Hastings, Melamed, & Lang, 1974). Startle magnitudes in general were also reduced post-treatment, and de Jong et al. (1991) found a reduction in startle response potentiation during the spider BAT following treatment. However, de Jong et al. (1993) found that startle response to probes during the spider BAT were still larger than those elicited during the wood or food item BAT after treatment. A further study using the similar methodology carried out by de Jong, Visser and Merckelbach (1996), found that the magnitude of the eye blink startle response could be used to predict success in treatment as measured by the SPQ, with relatively large startle potentiation in the presence of a spider being associated with relatively poor treatment outcome.

Hamm, Cuthbert, Globisch and Vaitl (1997) measured the physiological responses of animal (either snake or spider) and blood-injury phobic participants when viewing their feared object. They found that startle eye blink responses to acoustic probes were potentiated when both groups were viewing their fear-relevant pictures, although in the blood-injury group this potentiation was not quite significantly different from the control group. SCRs and heart rate were also found to be higher in the animal phobic group compared to the control group when viewing fear-relevant pictures, although these responses were not observed in the blood-injury phobic group. Nevertheless, this study (Hamm et al., 1997) gives some support to the motivational priming hypothesis that fear potentiated startle is an index of an organism's basic motivational state.

These studies provide considerable evidence that the magnitude of the startle reflex and SCR increase with arousing aversive/threatening stimuli. They therefore provide preliminary support for the predictions of the models based on animal research discussed above. Threatening stimuli do seem to elicit physiological signs of defensive activation, as seen by a potentiated startle response and increased SCR magnitudes. However, none of these studies has investigated the issue of the different stages of defence activation depending on the perceived proximity or degree of intensity of the threat.

One study which has looked at the effect of negative stimuli of different intensities on physiological responses was carried out by Bradley, Codispoti, Cuthbert and Lang (2001). They measured affective responses while participants viewed pictures with varied emotional and neutral content, with startle probes occurring between 3s and 5s of a 6s picture presentation period. They found that the most aversive and arousing pictures (e.g. violent attack and mutilation) resulted in the largest SCRs and elicited the greatest startle eye blink potentiation to the acoustic probes. Less aversive slides (e.g. pollution and loss) elicited only modest SCRs, large initial heart rate deceleration, and no startle eye blink potentiation. These results provide some initial support for the models based on animal research (e.g. Fanselow, 1994; Lang et al., 1997) discussed above because they differentiate between an initial risk assessment period to less arousing threat (as indexed by no startle blink potentiation and only modest SCRs) and a defence response to the most arousing threatening stimuli (as indexed by the largest SCRs and startle blink potentiation).

Overall, there have been very few studies which have looked at the effect of threat intensity. As has been covered above, there is considerable evidence to support the idea that threatening stimuli elicit greater startle response magnitudes and SCRs, but how these responses are affected by different intensities or proximities of threat stimuli remains to be researched thoroughly. Nevertheless, the models covered so far all suggest that threat stimuli of different perceived proximities should elicit different physiological, cognitive and behavioural responses.

Theoretical Models based on Cognitive and Clinical Research

The various models discussed so far, based on animal research, identify different processes and responses which are elicited by different types of threatening stimuli. They differentiate between an initial orienting, vigilant and risk assessment stage which is elicited upon first encountering a potential, distal and less arousing threat, and a subsequent defensive action stage which occurs in response to a direct, proximal, and arousing threat. Models based on cognitive and clinical research also make predictions about the responses elicited by threatening stimuli. These models are based on work done studying anxiety disorders in humans and deal mainly with biases towards threat, in particular biases in the allocation of attention.

Cognitive models which have been developed from a clinical perspective place great importance on the part that biases in information processing play in the development and maintenance of emotional disorders. Beck (1976) developed one of the first cognitive theories of emotional disorders based upon clinical observations and which provided the basis for cognitive treatments. He characterised emotional disorders in terms of "schemata", cognitive structures which influence how an individual perceives, interprets and remembers events. Depression is thought to be linked to negative schemata about the self, the world and the future, whereas anxiety is associated with negative schemata about vulnerability and danger. Through these negative schemata, all experiences become distorted. Beck (1976) thought that differences in vulnerability to emotional disorders could be explained by individual differences in the existence and operation of these schemata. For example, an anxious individual would have hyperactive negative schemata concerning danger. These would lead to an attentional bias for threat cues, a bias to interpret ambiguous information as threatening, and a bias for memories of threatening events.

Bower (1981) developed a network model of emotions in which each emotion has a specific memory node. These nodes are built up in associative networks in memory with all aspects of events connected to them. Therefore, activation of a particular emotional node increases the accessibility of all the nodes associated with it. This produces a processing bias for information that is congruent with the individual's emotional state. For example, an increase in anxiety would lead to greater access to threat-related memories. Both Beck's (1976) and Bower's (1981) models make the similar predictions that anxiety and depression are associated with emotion-congruent bias in all aspects of information processing; attention, interpretation and perception, and memory. In anxiety these biases are associated with danger, whereas in depression they are associated with failure.

More recent models have built upon these original ideas, and taken into account newer empirical evidence. The most relevant of which is that anxiety seems to be related most strongly with biases for threat in attention, and depression with biases for negative information in memory.

Williams, Watts, MacLeod and Mathews (1988, 1997) proposed a revised cognitive model of anxiety[1]. Their model characterised anxiety in terms of a bias for threat stimuli in preattentive processes and selective attention. At the preattentive stage of processing, the Affective Decision Mechanism (ADM) assesses the affective valence of a stimulus. Based upon this assessment, the Resource Allocation Mechanism (RAM) then determines the processing priorities, with resources being allocated either towards or away from particular stimuli. They claim that low trait anxious individuals will orient their attention away from threatening stimuli in order to limit increases in anxiety. However, high trait anxious individuals will shift attentional processing towards threat (see Figure 1.2 below).

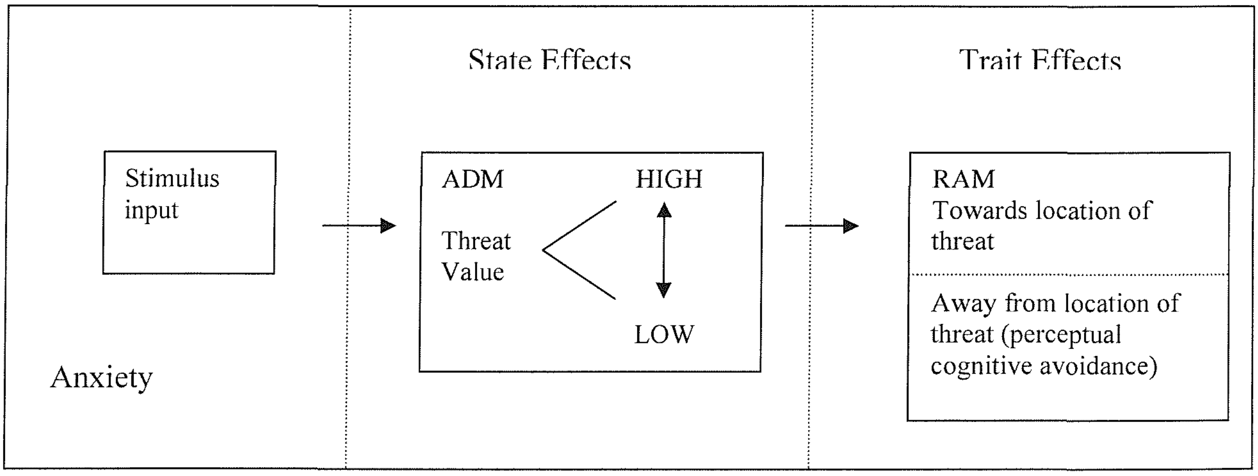

Figure 1.2: Model adapted from Williams et al. (1988)

Mogg and Bradley (1998) put forward a cognitive-motivational model of anxiety. This model postulates that the critical cognitive process involved in the susceptibility to anxiety is the evaluation of the valence of a specific stimulus (see Figure 1.3 below). The result of this evaluation then determines the allocation of attention either towards or away from the specific stimulus. The model proposes the

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[1] They also propose a cognitive model of depression, but this is outside the scope of this thesis

existence of two motivation-related mechanisms which result in the biases in the initial orienting of attention to threat. First, the Valence Evaluation System (VES) assesses the threat value of a specific stimulus; a process which is influenced by numerous factors including the specific stimulus itself, the situational context, the anxiety state of the individual, prior learning experiences, and biological preparedness. The level of trait anxiety of the individual reflects the reactivity of the VES to aversive stimuli, therefore in high trait anxious individuals the VES is more "sensitive" and is, therefore, more likely to evaluate any given stimulus as having a higher subjective threat value than it would be given by the VES of a low trait anxious individual. The output from the VES feeds into the Goal Engagement System (GES), which determines the allocation of resources for cognitive processing and action in response to the stimulus.

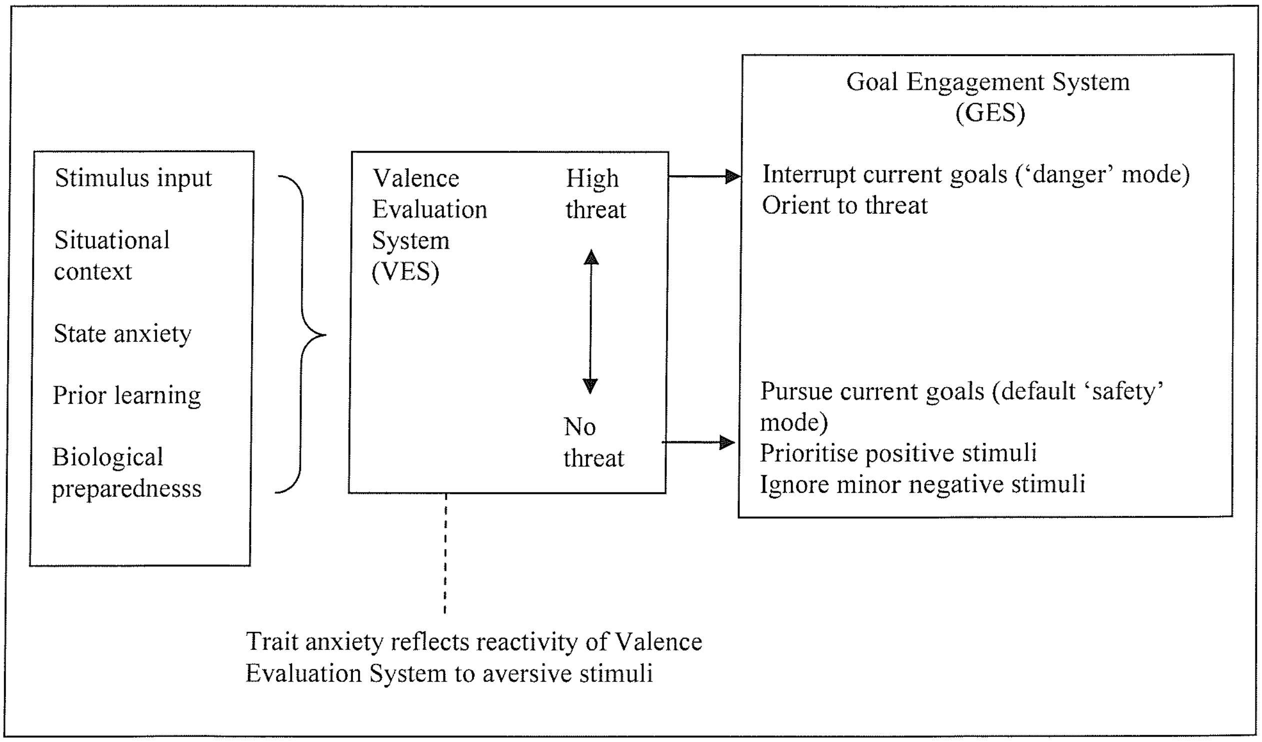

Figure 1.3: Cognitive-motivational model of initial orienting to threat in anxiety, adapted from Mogg and Bradley (1998).

Therefore, a stimulus which is evaluated as being a high threat by the VES, would subsequently be allocated a larger amount of resources, including attention, by the GES than a low threat evaluated stimulus. And as the evaluated valence of the stimulus increases, so too does the likelihood that attention will be allocated to it by the GES (see Figure 1.4 below). Therefore, unlike the Williams et al.'s (1998; 1997) model, Mogg and Bradley's (1998) model place the influence of trait anxiety on the activity of the mechanism which evaluates stimulus valence, rather than the mechanism which is responsible for the allocation of resources. Therefore, in cases of real danger, both low and high trait anxious individuals should exhibit an attentional bias for threat. The attentional bias to threat stimuli (e.g. threat-related words or facial expressions) observed in high trait anxious individuals, and not in low trait anxious individuals, is explained by the model as the result of the action of the GES reacting to a higher-threat evaluation of the stimulus by the VES. The VES of normal individuals would not evaluate the same stimulus as being of as high a threat, and so the GES would be less likely to allocate processing resources to it. Therefore the attentional bias to threat would not be found. The subjective evaluation of threat value of a stimulus by the VES is therefore the determining factor in the allocation of attentional resources by the GES.

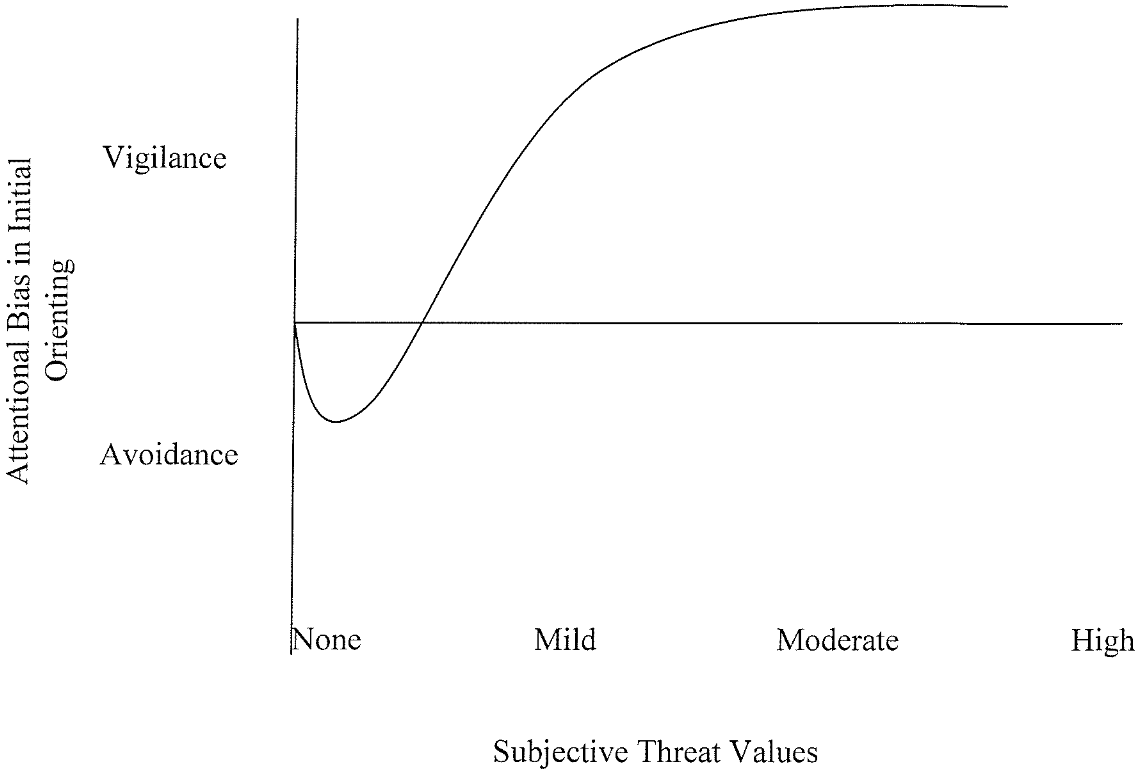

Figure 1.4: Hypothetical relationship between initial attentional bias and the subjective threat value of stimuli, adapted from Mogg and Bradley, 1998.

Another feature of Mogg and Bradley's (1998) model is the vigilance-avoidance hypothesis (see also Mogg, Mathews, & Weinman, 1987). This proposes that the initial vigilance for threatening stimuli can be lost when stimuli are sufficiently threatening. According to this view, the maintenance of attention to threat stimuli may be overridden by response tendencies to avoid the threat, for example, in order to reduce subjective discomfort and/or danger – e.g. averting eyes from distressing scene or escaping from a potential threat (see also Mogg & Bradley, in press).

Mathews and Mackintosh (1998) put forward a model to explain how vulnerability to anxiety is associated with different information processing styles in situations of stress. This model suggests that internal representations of stimuli compete for attention in a nonconscious selection system. It is the dominant representation, in terms of level of activation, which captures attention and becomes available to conscious awareness. In a normal situation, representations relevant to whatever task the individual is performing are activated, and representations of unnecessary distractors are inhibited. However, if the distractors match information associated with threat, for example, due to biological preparedness or prior learning, then these can capture attention instead. Therefore it is possible for stimuli to activate fear responses without the need for higher level processing or conscious awareness. Mathews and Mackintosh (1998) explain individual differences in vulnerability to anxiety under stress as a result of the threat evaluation system providing activation for the representations which match internal representations of threat. The resulting level of activation of these threat representations means that they can dominate the other representations which were activated by the demands of the task. Therefore, the information entering conscious awareness will be mainly threat-related and state anxiety will increase (see Figure 1.5 below).

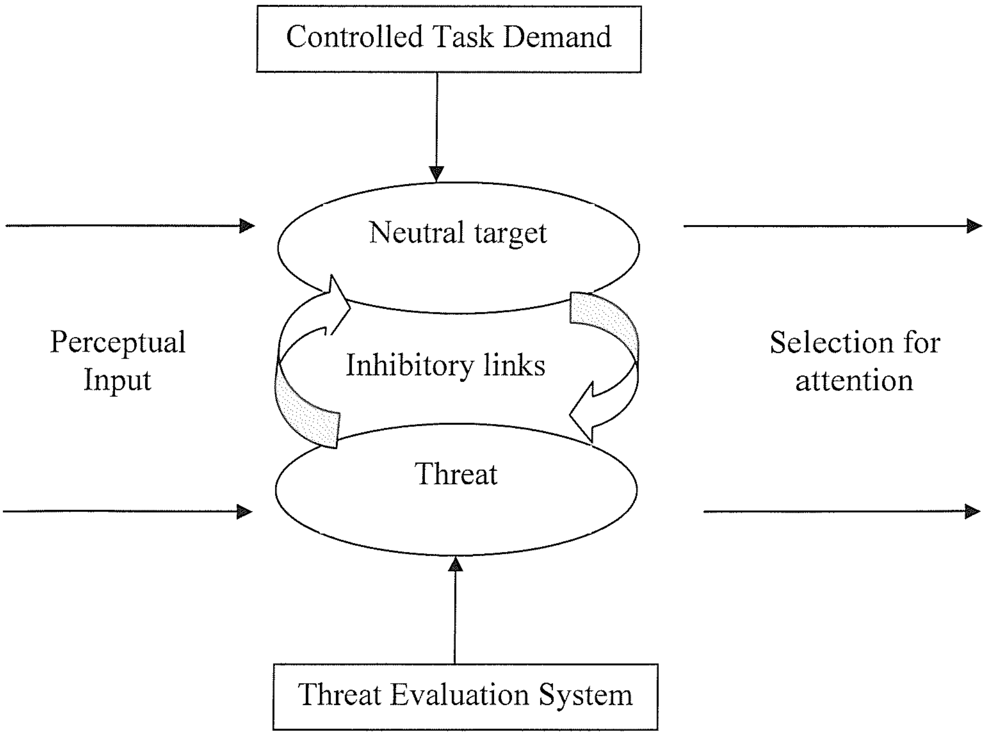

Figure 1.5: Model adapted from Mathews and Mackintosh (1998)

Recent work has led to the suggestion that "anxiety has a preconscious, automatic influence on attention" (Mineka & Sutton, 1992, pg. 65). Indeed, this idea has been encompassed in the cognitive models put forward by Williams et al. (1988) and Mathews and Mackintosh (1998). In this view, the processing of aversive/threatening stimuli may occur and elicit responses before the individual is consciously aware of the stimulus. This preconscious processing is thought to be mediated by a biologically prepared mechanism that is sensitive to innate stimuli (Öhman, 1994, 1996; Öhman & Mineka, 2001).

Öhman (1994, 1996) put forward a model (see Figure 1.6 below) which shows how stimuli of a threatening nature can be detected, analysed and elicit a fear response, before conscious perception of the threat stimulus is achieved. First, information from the outside world is passed through a set of feature detectors, which provide a preliminary segregation of stimuli based on their features, before they are more fully analysed. Then, an evaluation of the significance of the stimulus takes place, based on particular feature detectors which are specifically tuned to evolutionarily determined threat. If such primed threat-related features occur in the stimulus array, attention is switched to evaluate their significance more closely. Furthermore, if they have been previously associated with aversiveness, the arousal system is activated automatically, leading to the deployment of defence behaviours. Conscious perception of the threatening stimulus only comes later from input from the arousal system of its activation, from the significance evaluator, and from the expectancy system which contains memorial representations of past experience with the stimuli involved, as well as their associations with threat.

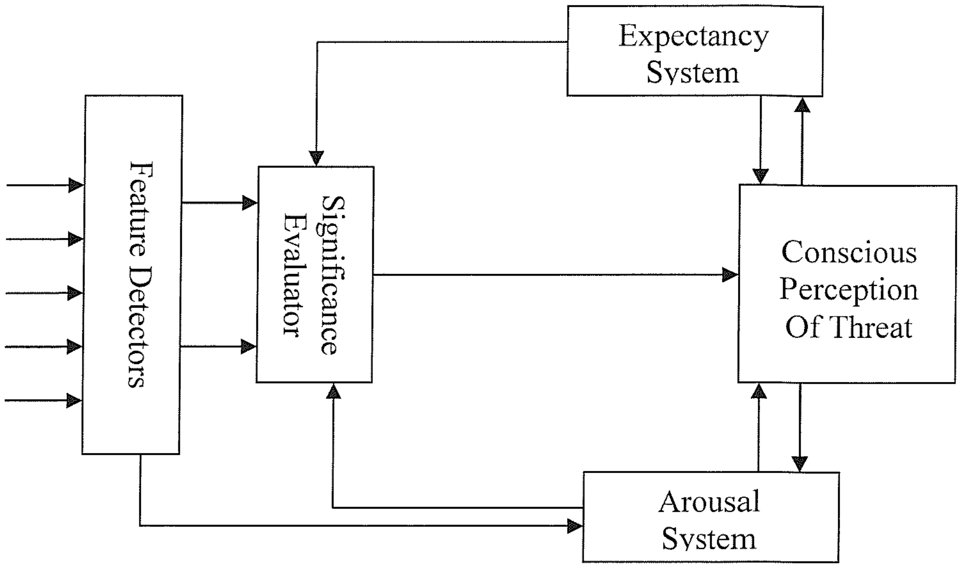

Figure 1.6: An information-processing model of the generation of fear, adapted from Öhman, 1994.

This model demonstrates how the pre-conscious processing of threat can occur and result in a defence response being activated. If this is the case, then the orienting response and sensory processing of potential distal threat, suggested, for example, by Lang et al.'s (1997) model, and the vigilance for threatening stimuli proposed by cognitive models of anxiety (e.g. Mogg & Bradley, 1998), may occur pre-consciously for threats of phylogenetic origin. Activation of the defence behaviours, such as avoidance, may then be triggered seemingly simultaneously with the conscious perception of the threat by the organism.

Öhman's (1994; 1996) model has recently been enlarged upon by Öhman and Mineka (2001). They propose that fear is a central aspect of mammalian evolution, and that our survival has depended on the development of a "fear module" which is an independent system of behavioural, mental and neural mechanisms which have evolved to help solve adaptive problems caused by life-threatening situations/stimuli in the history of our evolution. This module comprises four characteristics that have been shaped by evolutionary contingencies. It is selective with regard to input, responding especially to threats of historic phylogenetic origin. It has an automatic response which can recognise and trigger defensive responses to threatening stimuli without conscious awareness. It is isolated from other processes which means that, once activated, it can run its course without interference from other systems and is therefore impenetrable to conscious control. Finally, it has a specialized neural circuitry, which have evolved over time and which give it the characteristics it exhibits.

Therefore, the fear module is part of an evolutionary perspective which sees fear and anxiety as products of an evolved defence mechanism designed to keep organisms away from life-threatening situations/stimuli. Evoking this defence system implies the action of the sympathetic branch of the autonomic nervous system, which provides energy and prepares the body for vigorous and potentially hazardous action. When people with simple phobias, or highly fearful participants, are confronted with their feared stimulus, there is an immediate phasic psychological response, which includes brief acceleration of HR, elevated SCRs and peripheral vasoconstriction. This initial phasic response to phobic material, which usually is terminated within 10 - 20 s, is followed by more long lasting tonic change in the direction of sympathetic activation. In this perspective, emotions can be seen as action dispositions (Lang, 1990) in which some situations or stimuli are attractive and prompt approach and others are aversive and prompt escape or avoidance.

Öhman (1994, 1996) and Öhman and Mineka (2001) report on a body of evidence in support of a primitive, automatic system operating outside and independent of conscious control. They cite LeDoux's (e.g. LeDoux, 1996) work as a neural basis for such a system.

LeDoux (1996) reports on the extensive research on fear conditioning in rats which has identified two separate pathways to the amygdala, each of which is activated by a conditioned stimulus. One is a rapid pathway which goes directly from the sensory thalamus to the amygdala, and a second is a longer pathway that goes through the sensory cortex. Normally, these two pathways work in parallel – the rapid pathway provides fast information about possible dangers, establishing "emotional memories" in the amygdala. The cortical pathway provides more exact information and enables comparisons with previous experiences. It also has access to the hippocampus in order to form explicit memories. LeDoux (1996) suggests that these pathways could provide a mechanism for the development of specific phobias.

There is a direct neural link between nuclei in the thalamus to the effector systems in the amygdala which provides immediate information to the amygdala about the broad features of emotionally relevant auditory stimuli. The use of this pathway bypasses both the thalamo-cortical pathway, which gives a full analysis of the stimulus, and the cortico-amygdala link, which is thought to activate emotion. This thalamic-amygdaloid pathway is described as a "quick and dirty" transmission route which does not provide much information about the stimulus detail, but informs the amygdala that the sensory receptors of a given modality have encountered a potentially significant stimulus so it can start to recruit a defensive fear response. Therefore, via this route, threat stimuli may be processed prior to conscious awareness.

Taken together, these models provide some predictions regarding the type of responses elicited by threatening stimuli, particularly in terms of attentional allocation. Williams et al. (1997), Mogg and Bradley (1998) and Mathews and Mackintosh (1998) predict that threatening stimuli capture the attention of high anxious individuals. The models also suggest that this bias gets stronger as the threat value of the stimulus increases, for example, were it to become more proximal. Mogg and Bradley (1998) and Mathews and Mackintosh (1998) also both predict that highly threatening stimuli would capture the attention of non-anxious individuals. However, in addition to the, Mogg and Bradley (1998) predict that highly threatening stimuli may elicit attentional avoidance, in order to escape the effects of the threat (i.e. the vigilance-avoidance hypothesis). Predictions are also made concerning the role of preconscious processing of threatening stimuli (Mathews & Mackintosh, 1998; Öhman, 1994, 1996; Öhman & Mineka, 2001; Williams et al., 1988). If certain types of threat stimuli can be processed prior to conscious awareness, then an active fear response can be activated very quickly. Predictions can be extrapolated from the various cognitive models discussed above (e.g. Mogg & Bradley, 1998; Öhman & Mineka, 2001) as to how an individual will respond as a threat increases in perceived proximity. In response to a distally perceived threat, an individual will display only minor attentional processing (i.e. no significant attentional bias when compared to the proximally perceived threat or enhanced eye movements). However, a proximally perceived threat would be expected to elicit strong and rapid initial attentional processing (e.g. an attentional bias or enhanced eye movements), which may then give way to subsequent avoidance behaviours (e.g. a negative attentional bias at longer probe times or shorter dwelling time on the proximal threat stimuli).

Attentional Responses to Threat

There are numerous studies which have assessed attentional responses to threatening stimuli. These studies have examined the patterns of initial attentional allocation towards or away from threat stimuli, and also how this pattern of attention develops over time. They also explore how these patterns differ in non-anxious participants, in individuals with high trait anxiety, in patients with various emotional disorders, and in individuals with specific phobias. This section will provide a review of some of the most relevant empirical evidence for the models discussed, with particular reference to the results from modified Stroop, dot-probe, and eye-movement studies. These studies have examined the pattern of initial and subsequent attentional allocation in response to threat, the effects on attentional allocation of stressors and manipulations of the threat intensity of a stimulus, the question of enhanced engagement of attention towards threat versus delayed disengagement, and the evidence for the preconscious processing of threat stimuli.

The Stroop and Visual Probe Tasks

A widely used paradigm for measuring the allocation of attention is the modified Stroop task. In this task, participants are presented with words of different colours. They are instructed to name the colour of the word as quickly as possible, ignoring its meaning. Since attentional resources are limited, it is proposed that colour-naming performance deteriorates if the meaning of the words demands attention. Thus, the more attention that is being automatically allocated towards processing the meaning of the word, the slower the colour naming. In the case of anxiety many studies have found such an interference effect in anxious subjects when colour-naming words related to their particular area of concern compared to non-anxious controls (e.g. Mathews & Klug, 1993).

There has been a great deal of research into anxiety-related Stroop effects (see Williams et al., 1996 for review). In general, such research has indicated that anxious individuals show interference when colour-naming stimuli of personal relevance to their concern (e.g. Mathews and Klug, 1993). For spider phobia in particular, many studies have shown that spider phobic participants are retarded on a modified Stroop task using spider words compared to non-phobic controls, but not on Stroop tasks using other emotional or control words (e.g. Watts, McKenna, Sharrock & Trezise, 1986; Thorpe & Salkovskis, 1997). Furthermore, this interference effect appears to be significantly reduced following several sessions of therapy (e.g. Kindt & Brosschot, 1997; Lavy, van den Hout & Arntz 1993; Lavy & van den Hout, 1993; van den Hout, Tenney, Huygens & de Jong, 1997). Other modified Stroop studies have found evidence of colour-naming interference in anxious individuals for threatening stimuli even in trials where the stimuli were not open to conscious perception (e.g. Bradley, Mogg, Millar & White, 1995; Mogg, Bradley, Millar & White, 1995; Mogg, Bradley, Williams & Mathews, 1993). These studies provide some support for the prediction of an initial attentional bias for threatening stimuli in anxious individuals, as proposed by the cognitive models of anxiety. However, the use of the Stroop paradigm to provide evidence for attentional bias has been criticised because the exact mechanisms which underlie the interference effect are not yet understood (see Williams, Mathews & MacLeod, 1996). It may not necessarily reflect an attentional bias for threat, but may instead reflect an attempt to avoid processing aversive information (de Ruiter & Brosschot, 1994).

Another widely used paradigm for examining the allocation of attention to threat stimuli is the visual probe task. In this task, participants are presented with a central fixation cross and then a pair of stimuli (pictures or words) for a given amount of time (e.g. 200, 500, or 1000 ms). The pictures (or words) are followed by a probe which is located in the place in which one of the previous pictures (or words) appeared. Participants are required to press a button in response to the probe. The paradigm works under the assumption than participants will be faster to respond to probes which appear in the location of the picture to which they were attending. MacLeod, Mathews and Tata (1986) conducted a visual probe task using emotional threat and neutral word stimuli. They found an attentional bias for the threat words in clinically anxious patients suffering from generalised anxiety disorder, and a trend for avoidance of the threat words in non-anxious control participants. Many studies have subsequently shown similar evidence of anxiety-related attentional biases (see Mogg & Bradley, 1998 for a review) but it is important to note that several studies have not found an attentional bias in anxious individuals (e.g. Merckelbach, Kenemans, Dijkstra & Schouten, 1993 (using a slightly different task); Wenzel & Holt, 1999).

Evidence of Initial Orienting Towards Threat

The visual probe task has allowed researchers to examine the initial orienting of attention towards threatening stimuli. Bradley, Mogg and Millar (2000) used a visual probe task with eye movement monitoring to assess initial attentional allocation to emotional face pictures. The reaction time data showed that participants with high and medium levels of state anxiety demonstrated an enhanced vigilance for the threatening faces compared to neutral faces, low state anxiety participants did not show this effect. Also, although many participants made few eye movements, those that did indicated that there was a concordance between reaction time and eye movement measures. Mogg, Millar and Bradley (2000) conducted a similar study looking at reaction times to probes and eye movements to emotional faces in normal participants and patients suffering from generalised anxiety disorder (GAD) and depressive disorder. Although in this study the reaction time data provided no significant results, the eye movement data showed that GAD participants were more likely to make their first eye movement towards a threat face than a neutral face compared to normal control participants and those with depressive disorder. The time taken to make a first eye movement (latency) to the threat faces was also quicker in the GAD group compared to the other two groups.

The visual probe task has also allowed researchers to examine the time course of the attentional bias by using different picture presentation times. Mogg, Bradley, De Bono and Painter (1997) conducted a visual probe task using threat and neutral word stimuli using 100, 500 and 1500 ms exposure times. They found that higher states of anxiety were associated with a greater attentional bias for the threat words. This state anxiety-related attentional bias was not significantly influenced by the exposure times of the words. Bradley, Mogg, Falla and Hamilton (1998) used pictures of happy, threatening and neutral faces in a visual probe task, using 500 and 1250 ms exposure times. They found an attentional bias in their participants with high trait anxiety for the threat faces compared to the neutral faces, which did not significantly differ across the two picture presentation times. Bradley, Mogg, White, Groom, and de Bono (1999) conducted a similar study comparing normal control participants with patients suffering from generalised anxiety disorder. The results showed that the anxious patients exhibited greater vigilance for the threatening faces relative to neutral faces when compared to control participants. Green, Williams and Davidson (2003) recorded visual scanpaths in order to provide an objective measurement of the viewing strategies employed by humans when processing emotional faces, specifically in order to compare threat-related facial expressions (fear, anger) with other emotional faces (happy, sad) and with neutral faces. They found that when compared to the non-threat faces, viewing strategies for anger and fear faces were characterised by increased distance between fixations (extended scanning), more fixations, with longer durations, to feature areas of the faces. They suggest that this extended scanning style of threat faces reflects a "vigilant" style of scanning, whereby longer saccadic eye movements may reflect heightened autonomic response to threat and increased foveal attention in feature areas may facilitate cognitive appraisals of the personal significance and direction of the threat.

Maintenance of Attention on Threat versus Subsequent Avoidance

Mogg and Bradley (in press) conducted a pictorial visual probe task using cat and spider pictures with picture presentation times of 200, 500 and 2000 ms. They found that participants with a high fear of spiders demonstrated an attentional bias for the spider stimuli at the 200 ms picture presentation time. However, this initial vigilance decreased as exposure time increased, with no significant bias observed in the longer exposure conditions. Mogg, Bradley, Miles and Dixon (in press) conducted a study to look directly at the predictions of the vigilance-avoidance hypothesis. They suggest that the reason previous studies (e.g. Bradley et al., 1998; Mogg et al., 1997) did not find any evidence for avoidance of threat after initial vigilance was because the threat stimuli used were not sufficiently threatening – for example, threat words or faces. In this study pictures of aversive threat scenes (e.g. violence and mutilation) were used in a visual probe task with display times of either 500 ms or 1500 ms. Results indicated that the high trait anxiety group demonstrated an initial vigilance for the high threat scenes (at 500 ms). However, although this initial vigilance diminished, there was no evidence for subsequent avoidance of the high threat scenes (at 1500 ms). If the groups were split on blood-injury phobia scores, participants with a high level of blood-injury fear did show significant avoidance of high threat scenes at 1500 ms, which was a reversal of their initial vigilance at 500 ms. These results support the prediction for initial vigilance for threat made by several cognitive models of anxiety (e.g. Mogg & Bradley, 1998; Mathews & Mackintosh, 1998) and the vigilance-avoidance hypothesis proposed by Mogg and Bradley (1998). Therefore, it does appear that initial vigilance for threat gives way to subsequent avoidance.

Evidence which further supports the prediction that initial vigilance for threat in highly anxious individuals gives way to subsequent avoidance comes from studies measuring attentional allocation using eye movement measures. For example, Hermans, Vansteenwegen, and Eelen (1999) examined the eye movements of spider anxious participants to spider and flower stimuli presented for 3000 ms. They found that spider anxious participants looked significantly more at the spiders than at the flowers for the first 500 ms of stimulus presentation, but that in the last 1000 ms they demonstrated avoidance of the spiders. Control participants were found to look more at the spiders than at the flowers throughout the presentation time. Similarly, Rohner (2002) showed high and low trait anxious individuals pairs of emotional faces whilst measuring their direction of gaze. During the first 1000 ms of the presentation of the stimuli, both groups were found to view angry faces more than happy faces. However this initial vigilance gave way to avoidance in the high trait anxious group, as between 2000-3000 ms of viewing time they averted their gaze from angry faces more than happy faces, compared to low trait anxious subjects.

Tolin, Lohr, Lee and Sawchuk (1999) investigated the idea that fear and anxiety serve as programmes for avoidance of threat-relevant stimuli. Spider phobics, blood-injection-injury phobics and nonphobics viewed six colour photographs of spiders, simulated injections and household appliances, having been told they were to attend to the pictures in preparation for a subsequent memory test. The time they viewed each pictures was measured. Results showed that phobic participants showed decreased viewing time towards their particular feared object. Finally, Pflugshaupt et al. (in press) recently conducted a study in which they monitored the eye movements of participants with spider phobics and non-phobic controls whilst asking them to search for spiders in a series of visual scenes. They found that, in line with the vigilance-avoidance hypothesis, the participants with spider phobia detected spiders faster and looked closer at them during the initial search phase, but then fixated their eyes further away from them compared to the non-phobic controls.

The Effect of Stressors on Attentional Allocation

There have been several modified Stroop studies which have looked at how stress affects the interference effect usually seen in anxious individuals. Mathews and Sebastian (1993) conducted a linguistic Stroop task consisting of snake words, threatening words and neutral words with high and low snake fear individuals with a snake present in the experiment room. They did not find the expected interference effects due to the snake-related words in the high snake fear participants under these conditions. They suggested that fear arousal might lead to a suppression of the Stroop effect as a replication without the presence of the snake did find the expected interference. In a third variation of the experiment they tested high snake fear subjects with a tarantula spider present in the experiment room. Half of the participants were told that they would be asked to take part in a behavioural task to see how close they could get to the spider. For those high snake fear participants who were not subjected to this fear manipulation, the expected interference effect was found, i.e. they were slower at colour-naming snake words than neutral words. However, for those participants being threatened, there were no differences in colour-naming speeds attributable to word type. Amir, McNally, Riemann, Burns, Lorenz and Mullen (1996) conducted a word Stroop task with clinical patients suffering from social phobia and non-phobic controls. Participants were asked to name the colour of social and physical threat words and matched neutral words. The study was done in two conditions, once in a non-anxious condition and again with an anxiety manipulation in which participants were told that they would be asked to give a speech. Results showed that the Stroop interference for the social threat words found in the non-anxious condition for social phobic patients was lost when they were undergoing the anxiety manipulation.

In contrast to these findings, Chen, Lewin and Craske (1996) conducted a linguistic Stroop task using spider-related, positive and neutral words. They tested spider-fearful and non-fearful control participants, who completed the Stroop task after a neutral condition and also after approaching a spider (a stress manipulation). They found that the spider-fearful participants showed increased Stroop interference to the spider words, and that this was increased after the stress condition. This suggests that state anxiety increases Stroop interference for threat information in fearful individuals.

Wikstrom, Lundh, Westerlund and Hogman (in press) conducted an unmasked and a masked linguistic Stroop on snake phobic and non-phobic controls. They also looked at how increasing the stress of the participants would affect their responses. Therefore, half of the phobic participants were given a stress manipulation in which they were told they would be asked to take part in a behavioural approach test (BAT) involving having to approach a live snake. The results showed that all phobic participants demonstrated Stroop interference for the unmasked snake words compared to the controls. However, there was no difference in Stroop interference between the stressed and non-stressed phobics. Also, there was no interference observed in the masked condition.

These studies highlight the fact that the results using stressors, to manipulate the anxiety levels of the participants, are mixed and difficult in interpret.

The Effect of Manipulating Threat Intensity

More recently, studies have examined how the attentional bias is affected by manipulating the intensity of the threatening stimuli used. This question is of more direct relevance to this thesis as the models based on animal research (e.g. Fanselow, 1994; Lang et al., 1997) predict that increasing the proximity, and therefore intensity, of a threatening stimulus will influence the responses it elicits. In two experiments, Mogg, McNamara, Powys, Rawlinson, Seiffer and Bradley (2000) used a visual probe task pairing mild and highly threatening stimuli with neutral stimuli. In the first experiment they used unselected participants and found the attentional bias was greater for the highly threatening scenes, than for the mild threat scenes. In the second experiment they selected high and low trait anxious participants. Here they found that irrespective of trait anxiety level, there was a greater attentional bias for high than low threat scenes. Wilson and MacLeod (2003) used a dot probe task with faces, pairing a neutral face with one of five different variations of morphed angry faces. The five morphed angry faces ranged in threat value from very low angry to very high angry. They found that both high and low trait anxious participants demonstrated avoidance of the very mild angry faces and an attentional bias for the very high angry faces. However, the high trait anxious group switched from avoidance to bias for threat for angry faces lower down the range of morphed faces than the low trait anxious group.

In contrast to these findings, Koster, Crombez, Verschuere and De Houwer (in press), who used a pictorial dot-probe in which mild and high threat scenes were paired with neutral scenes, found that normal participants demonstrated an attentional bias for both the mild and the high threat pictures.

Facilitated Engagement of Attention Towards Threat versus Delayed Disengagement

Recently there has been some debate concerning what exactly the visual probe task is measuring. Fox, Russo, Bowles and Dutton (2001) suggest that instead of threat-related stimuli drawing attentional resources, attentional processes actually take longer to disengage from threat-related stimuli. Fox et al. (2001) used the exogenous cueing paradigm in which subjects are required to detect a target that may appear to the left or the right of a central fixation point. On some trials, a cue indicated the area in which the target would appear, but the cue was only a valid predictor 80% of the time. The valence of the cue was manipulated. Across five studies, the cue was a word or face that was either neutral, positive or threat-related, while the target was a circle. Participants were high or low state anxious individuals. They found consistent results to support the hypothesis that the presence of threat-related stimuli affects the disengagement component of visual attention. It was found that threat-related words slowed down reaction times to targets on invalid cue trials relative to positively valenced or neutral words. Thus, the presentation of a threat word seemed to increase attentional dwell time at that location by disrupting the localization of the target when it appeared in another location. Fox, Russo and Dutton (2002) further investigated the enhanced dwell time hypothesis to see whether the delay in disengagement from the location of threat is affected by an individual's level of trait anxiety. Their results also suggest that people, especially anxious individuals, take longer to disengage from threat-related stimuli, such as angry facial expressions and threatening pictures. Similar results have also been found by Yiend and Matthews (2001) in anxious individuals and by Amir, Elias, Klumpp and Przeworski (2003) for social threat words in participants with social phobia. Recently, Koster et al. (in press) compared reaction times on congruent and incongruent threat trials with reaction times on neutral trials in a visual probe task. They also found that the pattern of reaction times for probes occurring in the place of threat pictures is consistent with a difficulty in disengaging from threat rather than a vigilance for threatening information.

Evidence for the Pre-conscious Processing of Threat

Empirical evidence for the existence of a preconscious processing of threat stimuli has used a method of backward masking, which allows a stimulus to be shown for a very brief period to a participant without the participant being consciously aware of the content of the picture. This is achieved by the stimulus being shown for a brief time and then being immediately followed by a mask (e.g. a jumbled pictorial mess of no discernible stimulus) which effectively hides the content of the previous picture from conscious perception. Studies using this paradigm have shown support for a preattentive processing of fear-relevant threatening stimuli.

There have been numerous studies using the modified Stroop paradigm with both masked and unmasked trials. Many of these studies have found evidence, in anxious and phobic participants, for interference in the colour naming of negative, threatening, or concern-related words and pictures (e.g. Bradley et al., 1995; Mogg et al., 1993; Mogg et al., 1995; Van den Hout et al., 1997; Van Honk et al., 2001). Also, in a masked linguistic Stroop task using negative and neutral words, Van den Hout, Tenney, Huygens, Merckelbach and Kindt (1995) found a significant correlation between trait anxiety and Stroop interference in the colour naming of the negative words. Studies using visual probe tasks have also found evidence of attentional biases for masked threatening stimuli (e.g. threatening faces) in high trait anxiety and high social anxiety (e.g. Mogg & Bradley 1999; Mogg & Bradley, 2001).

Öhman & Soares (1994) exposed spider and snake fearful and non-fearful participants to pictures of snakes, spiders, flowers and mushrooms. They recorded skin conductance responses (SCRs) to masked and non-masked versions of these picture conditions. They found that snake and spider-fearful participants showed elevated SCRs to snake and spider pictures compared with neutral pictures and with responses of the non-fearful subjects under both masked and unmasked conditions. Ratings of valence, arousal and dominance also indicated that the fearful participants felt more negative, more aroused and less dominant in relation to both masked and non-masked phobic stimuli. Similarly, Öhman & Soares (1993) conditioned half of their participants to fear-relevant stimuli and half to fear-irrelevant stimuli. They showed that both groups showed reliable differential SCRs to the shock conditioned stimulus (CS+) and the non-shock conditioned stimulus (CS-) when shown them afterwards without the masks. This suggests that the conditioned effects continued in both groups (i.e. the responses to the fear-relevant and fear-irrelevant stimuli conditioned with a shock differed from the responses to fear-relevant and fear-irrelevant stimuli not conditioned with a shock). However, when they were subsequently shown the CS+ and the CS- with masks, fear relevance did make a clear difference. Whereas masking completely abolished differential responding in the group conditioned to fear-irrelevant stimuli, the differences in responding remained in the group conditioned to fear-relevant stimuli. These participants showed differential psychophysiological responses between shock-associated control and fear-relevant stimuli even though they were not consciously aware of the stimulus content. Soares and Öhman (1993) showed that participants who were conditioned to fear-relevant stimuli showed this differential responding during the extinction phase to masked pictures, even when they were explicitly told that no shocks would be given during the extinction phase. However, participants conditioned to fear-irrelevant stimuli showed no differential responding during extinction. These studies provide evidence to support the notion of the pre-conscious processing of threat and fear-relevant stimuli.

Further studies have investigated the notion of efficient, or even pre-conscious, processing of fear-relevant stimuli. Such studies have examined the rapid selection of such stimuli from complex visual displays – visual search paradigms. Fox et al. (2000) conducted a series of visual search experiments in which participants had to decide whether matrices of schematic faces were all the same or had a discrepant face. They found consistently that when all the faces were the same, participants were slower at detecting this when all the faces were angry compared to when they were happy or neutral. They also found that when the matrix contained a discrepant face, participants were faster at detecting this if the discrepant face was angry compared to when it was happy or neutral. These effects were found to be related directly to the emotion being expressed as the same effects were not observed when the faces were presented upside down (and so therefore preventing holistic processing of the emotion) or when certain features, such as the curved mouths, were presented alone and not in the context of a face. However, although they found that identifying a discrepant angry face was less affected by the number of distractors than identifying a discrepant happy face, they could not conclude that the search for threat occurred in parallel. Nevertheless, this series of studies provides evidence for a system capable of rapid and efficient detection of threat.

Öhman, Lundqvist, and Esteves (2001) used a similar visual search task in which participants had to search for discrepant faces in matrices of otherwise identical faces. Across five experiments, the results also consistently showed faster and more accurate detection of threatening faces compared to friendly faces. The threat advantage was obvious regardless of whether the conditions involved neutral or emotional distractors. Interestingly, unlike Fox et al. (2000), they found that the threat advantage remained even when the schematic faces where inverted (so that the individual parts, for example the mouth and eyebrows of the positive face where displayed like those of an upright negative face and vice-versa). The threat faces were also detected more quickly and accurately than other schematic negative faces (e.g. sad or scheming), suggesting that the threat advantage can be attributed to threat rather than to the negative valence or the uniqueness of the target displays.

Öhman, Flykt and Esteves (2001) had participants search for discrepant fear-relevant (snakes or spiders) or fear-irrelevant (flowers or mushrooms) pictures. Fear-relevant pictures were found much more quickly than fear-irrelevant ones. Fear-relevant, but not fear-irrelevant, search was unaffected by the location of the target in the display and by the number of distractors. This suggests that parallel search is occurring for fear-relevant targets and that serial search is occurring for fear-irrelevant targets. Participants specifically fearful of snakes but not spiders (and vice-versa) showed facilitated search for the feared objects but did not differ from controls in the search for non-feared fear-relevant or fear-irrelevant targets. They concluded that evolutionary relevant threatening stimuli were effective in capturing attention, and this effect was further facilitated if the stimulus was emotionally provocative. These studies seem consistent with the view that fear-relevant threatening stimuli capture attention and are processed preferentially and very rapidly.

Globisch, Hamm, Esteves and Öhman (1999) conducted a startle probe task measuring eye blink magnitude, SCRs, heart rate and blood pressure in spider- and snake-fearful and non-fearful control participants. The results indicated that fear-specific startle potentiation starts very early during picture processing and persists, regardless of whether the threat cue is present or absent. Significant startle potentiation was found in the high fear groups as early as 300 ms after onset of the fear-relevant pictures. This fear potentiated startle was also associated with strong sympathetic activation at both a 6s picture presentation time (eliciting increases in SCR, blood pressure and heart rate) and a 150 ms picture presentation time (eliciting increases in SCR and heart rate). Thus, fear-specific startle potentiation appears to start very early during picture processing and persists, regardless of whether the threat cue is present or absent. This suggests that the fear network can be accessed very rapidly and with minimal stimulus input, and is associated with sympathetic activation and mobilization of defensive behaviour to the level of protective reflexes.

Merckelbach, de Jong, Leeuw and van den Hout (1995) also looked at physiological responses by measuring startle eye blink responses to masked stimuli. They showed spider-phobic and control participants pictures of spiders, snakes, flowers and mushrooms under conditions of backward masking. Although the spider-phobic participants did not show larger startle responses on all the spider trials, in the second block they did show a potentiated startle to the spiders compared to control participants, with no differences in the magnitudes for the control stimuli. This result provides partial support for the idea that an active defence response can be activated by threat stimuli even when they are not accessible by conscious awareness.

Summary of Findings

The general findings of these studies indicate an enhanced initial attentional processing of threatening stimuli, be they words or pictures, in anxious participants. This initial attentional bias has been found for both high state and trait anxiety, as well as for individuals with specific phobias, or patients suffering from generalised anxiety disorder. Some studies suggest that highly threatening stimuli also prompt enhanced attentional processing in non-anxious participants. The effect that stressors have on the allocation of attention has been mixed, with some studies showing a loss of Stroop interference effects and others an enhancement. Increasing the threat value of threatening stimuli, on the other hand, has been shown to lead to an enhancement of the attentional bias. There is also some evidence to suggest that the initial bias for threatening information gives way to subsequent avoidance.

The studies dealings with preconscious processing seem largely consistent with the proposal of a perceptual system which automatically and pre-consciously, or at least very rapidly, focuses attention on potentially threatening stimuli when the threat has a likely origin in biological evolution. Responses to such stimuli, such as increased SCRs and potentiated startle eye blinks, can be recruited at a very early stage of processing and so the defensive response may be elicited before conscious awareness.

While some studies have manipulated the content of the pictures to investigate attentional biases for threat cues, none of these studies address the issue of how increasing the proximity of a threat stimulus will affect the response it elicits. Given that, according to some models (e.g. Fanselow, 1994; Lang et al., 1997), perceived proximity plays an important part in determining the type of defensive behaviour elicited by a threat stimulus, it is important that this question is addressed.

Implicit Measures of Valence – A Measure of Behavioural Responses?

Thus far the models and empirical work discussed have concentrated on physiological and attentional responses to threat. However, the various models discussed also make predictions concerning the behavioural responses to threat. The models based on the animal research in particular (e.g. Lang et al., 1997; McNaughton & Gray, 2000) predict that it is only proximally perceived threat which will elicit the active behavioural responses, such as the fight-or-flight response. There is an interesting methodology coming from research into implicit attitudes which may help address the question of how behavioural responses are influenced by threat imminence.

The affective Simon task (AST) was developed by De Houwer and Eelen (1998) in order to examine the implicit evaluation of affective properties of stimuli. By taking a measure of implicit attitudes concerning valence some of the problems involved with the direct measures of attitudes can be avoided, such as deception, self-presentational strategies and response bias (De Houwer, 2002). Participants are asked to process a relevant feature of a stimulus in order to select the correct response, whilst ignoring an irrelevant feature that is meaningfully related to the response but not the relevant feature. For example, De Houwer and Eelen (1998) had participants classify words by responding "positive" to nouns and "negative" to adjectives. However, the words themselves were also positive or negative in terms of valence. So, although participants had to respond by saying either "positive" or "negative", the correct response was dependent not on the valence of the word (the irrelevant feature) but on whether it was a noun or an adjective (the relevant feature). They found that the reaction times of participants were faster when the correct response matched the valence of the stimulus, even though participants were instructed explicitly to ignore the valence of the stimulus. Other studies using the affective Simon task, or variants of it, have found similar results (e.g. Tipples, 2001). These results indicate that the valence of the stimulus is processed automatically in the sense that the processing is rapid, unintentional and relatively efficient (Moors & De Houwer, 2001).

Another task which examines implicit associations is the Implicit Attitudes Test (IAT; Greenwald, McGhee, & Schwartz, 1998). The IAT works by having participants classify words or pictures into categories. Greenwald et al. (1998) had participants sort flower words, insect words, pleasant words and unpleasant words by pressing a key on the left or the right side of a computer keyboard. The implicit attitudes held by the participants concerning the categories were assessed by comparing differences in responses times when pleasant words and flower words shared the same key compared to when unpleasant words and flower words shared the same key. Like the AST, they found that participants were in general much faster to categorise stimuli when the paired categories were congruent; for example when the response key to flower words and positive words was the same. Likewise, participants were slower when the paired categories did not match; for example, when the response key to insect words and positive words was the same.

Both the AST and the IAT have been used to assess implicit valence evaluations of phobic participants (e.g. de Jong, van den Hout, Rietbroek & Huijding, 2003; Teachmann, Gregg & Woody, 2001; Teachmann & Woody, 2003). In general, phobic participants have demonstrated automatic associations between pictures of their feared animal and negative categories such as negative valence, fear, danger and disgust. These studies indicate that implicit measures of the subjective evaluation of stimulus valence can be assessed using tasks such as the IAT and the AST.

However, it is a newer version of the AST that is of particular interest to the question of behavioural response. De Houwer, Crombez, Baeyens and Eelen (2001) conducted a series of experiments looking at the generalisability of the AST. In one experiment a valenced non-verbal response (i.e. a symbolic approach or avoidance response) was used rather than a verbal one. Positive and negative nouns and adjectives were presented one by one on the screen. Before the onset of the word, a manikin appeared above or below the position where the word would appear. Participants could make the manikin run up or down by pressing keys. They were either instructed to make the manikin run towards nouns and away from adjectives or vice-versa. They then measured the time between the appearance of the word and the first key press. It was assumed by the authors that making the manikin run away was equivalent to avoidance or an escape response, and as such can be linked to responses to negatively valenced stimuli. Making the manikin run towards the stimulus was considered to be analogous with approach behavioural tendencies, and as such is linked with responses to positively valenced stimuli. They predicted that participants would take longer to make the manikin run away from positive words and towards negative words than vice-versa, even though the valence of the words was irrelevant to the task. The results showed that mean reaction times on congruent trials (where participants had to make the manikin run towards positive words and away from negative words) were significantly shorter than reaction times on incongruent trials (where participants had to make the manikin run away from positive words and towards negative words). These results suggest that the evaluation of stimulus valence can be assessed from behavioural approach-avoidance tendencies.

This task was modified by Mogg, Bradley, Field and De Houwer (2003) and also by Bradley, Field, Mogg and De Houwer (2004) to assess implicit attitudes to smoking-related pictures and control pictures in smokers and non-smokers. Mogg et al (2003) found that smokers were faster to make approach, rather than avoidance, responses to smoking-related pictures, and this bias was significantly greater than that found in non-smokers. Similarly, Bradley et al. (2004) found that smokers demonstrated a bias to approach, rather than avoid, smoking-related pictures whereas non-smokers showed no such bias.

These results suggest that different types of motivationally relevant stimuli can influence the behavioural tendencies of an individual. Studies have used the manikin version of the affective Simon task to investigate the processing of stimulus valence (e.g. de Jong, van den Hout, Rietbroek, & Huijding, 2003) and the processing of appetitive stimulus, such as drug cues (Bradley et al., 2004; Mogg et al., 2003). The manikin version of the AST also allows behavioural action tendencies in response to stimuli to be measured. Therefore, using this task the approach and avoidance responses to different kinds of threat stimuli could be assessed. However, no study so far has examined this issue. Given that the various models discussed (e.g. Fanselow, 1994; McNaughton & Gray, 2000) make predictions concerning the approach and avoidance responses elicited by threat stimuli at different proximities, this is an important issue.

Aims and Objectives

The aim of the experimental work in this thesis is to examine the responses elicited by threatening stimuli and how these responses are affected by changes in perceived proximity. By varying the perceived proximity of the threatening stimuli, it is hoped to be able to further elucidate the different processing and defensive responses elicited by threatening stimuli in humans.

The various models discussed earlier provide a basis for generating predictions as to how an increase in threat proximity will affect the responses elicited. The models based on animal research (e.g. Fanselow, 1994; Lang et al., 1997; McNaughton & Gray, 2000) all differentiate between the sensory processing responses elicited by distal and mild threat and the active defence responses (i.e. fight-or-flight) elicited by proximal threat. The cognitive models of anxiety (e.g. Mogg & Bradley, 1998; Mathews & Mackintosh, 1998) predict that increasing the threat value of a stimulus (e.g. by increasing its proximity) will lead to a greater degree of attentional processing. However, if the threat value is sufficiently high, this attentional vigilance can give way to avoidance (Mogg & Bradley, 1998). Indeed, if certain threat stimuli can be processed prior to conscious awareness (e.g. Öhman, 1996; Öhman & Mineka, 2001) an active defence response may be activated very rapidly.

The thesis will look in particular at attentional and physiological measures, as well as examining the behavioural approach/avoidance tendencies such stimuli induce. It will conclude with a discussion of the different behaviours exhibited by humans in response to proximally and distally perceived threat stimuli, and how these lend support to the predictions of various models of fear and anxiety.

Chapter Two: Study 1: The Allocation of Attention towards Proximally and Distally Perceived Stimuli in Spider Fear – a visual probe task

Abstract

The aim of this study is to examine the effect of the perceived proximity of a threat cue on the initial allocation of attention. Various models of fear and anxiety make predictions as to how attention will be affected. This study used a visual probe task with groups of high and low spider-fearful participants. The perceived proximity of the spider and the control stimuli were experimentally manipulated. The results did not show a difference between the two fear groups in their attentional responses to the spider pictures in general, even though they did rate the threat value of the spider stimuli differently depending on their perceived proximities.

Introduction

The models discussed in *Chapter One* give rise to predictions as to how attention is initially captured by stimuli of different threat intensities and perceived proximities. The issue of the perceived proximity of a threatening stimulus is of importance to several models of fear and anxiety (e.g. Blanchard & Blanchard, 1988; Fanselow, 1994; Lang, Bradley & Cuthbert, 1997; McNaughton & Gray, 2000). Two distinct types of defence behaviour have been observed in response to a threat stimulus, depending on its proximity to the organism (e.g. Fanselow, 1994; Lang et al., 1997). As was discussed in *Chapter One*, Blanchard and Blanchard (1988) characterise the defence behaviours of mammals in response to a threat into two classes. An actual, imminent threat elicits active defence behaviours, such as escape or attack, if escape is not possible. However, a distal or potential threat elicits vigilant and risk assessment behaviours. These include the organism interrupting its current behaviour in order to orient its attention towards the distant predator. If the predator continues to approach, this vigilance will then give way to the active threat/attack behaviours or escape. Fanselow (1994) draws a similar distinction, in which it is a threat's imminence (i.e. its spatial and temporal distance from the organism) which determines the type of defence behaviour it elicits.

Gray and McNaughton (1995) also propose a similar distinction between the types of defensive behaviours exhibited in response to threatening stimuli. They propose a hierarchical system in which distal threat results in behavioural inhibition and risk assessment behaviours. Proximal threat, however, results in a fight-or-flight response. This distinction is enlarged upon by McNaughton and Gray (2000), when they suggest that it is anxiety, which involves the risk assessment behaviours described by Blanchard and Blanchard (1988), which enables an animal to enter or remain in a potentially dangerous situation. Fear, on the other hand, which involves the fight-or-flight behaviours, is what motivates an animal to escape from a dangerous situation.

Lang, Bradley and Cuthbert (1997) also carry on the arguments put forward by Blanchard and Blanchard (1988) and Fanselow (1994). They claim that a distal threat elicits defensive immobility in an organism. This involves a freezing of current behaviour and hypervigilance directed towards the distal threat. Defensive action, which involves the fight-or-flight response, is elicited in response to imminent threat. They propose the defence cascade model which describes the levels of various physiological measures which provide an index of orienting and defence responses in humans. These responses change as a threat stimulus increases in intensity, which is seen as being analogous to a threat's imminence. A distal, low intensity threat leads to enhanced attentional processing of the stimulus. However, as the threat's intensity and proximity increases, this oriented attention gives way to active defence behaviours. This process is seen by Lang et al. (1997) as a "staged transition from attention into action" (pg. 128).

Taken together, this work presents a view of a defence system which is divided in its output into two broad categories. Which category of behaviours is elicited by a threatening stimulus depends on its proximity and intensity. Distal threats elicit attentional processing and risk assessment. However, proximal threats elicit the active defensive responses.

Other models also make predictions concerning the initial attentional bias for threatening stimuli (e.g. Mogg & Bradley, 1998; Mathews & Mackintosh, 1998). These models suggest that as threat value increases, the initial attentional bias for the threat stimuli will also increase. For example, Mogg and Bradley (1998) postulate that the evaluation of the valence of a stimulus is important in determining the extent to which attention is initially allocated. However, it is also suggested that the initial attentional bias for threat, proposed by these cognitive models, can be overridden by avoidance of threat in certain circumstances. Mogg and Bradley (1998) include the vigilance-avoidance hypothesis in their model. This states that the initial vigilance for a threatening stimulus may be subsequently lost when stimuli are sufficiently threatening. Therefore, the maintenance of attention to threat stimuli may be overridden by response tendencies to avoid the threat. For example, in order to reduce subjective discomfort an individual may avert their eyes from a fear-relevant scene. Similarly, Öhman (1996) suggests that attention is initially automatically captured by innate fear stimuli because of our evolved defence system which allows for the rapid identification of threat (e.g. Öhman, Flykt & Esteves, 2001; Öhman, Lundqvist & Esteves, 2001; Öhman & Mineka, 2001). As the primary function of such a system is to ensure survival, the rapid identification of a threat would lead to the subsequent activation of escape responses and avoidance.

There have been several studies which have examined how manipulating the intensity of threat influences initial attentional allocation. For example, Mogg, McNamara, Powys, Rawlinson, Seiffer and Bradley (2000) and Wilson and MacLeod (2003) find that increasing the threat value of a stimulus intensifies the amount of attention it receives. There has also been empirical evidence to suggest that the initial allocation of attention towards threat subsequently gives way to avoidance. For example, Tolin, Lohr, Lee and Sawchuk (1999) found that spider-fearful participants spent less time viewing spider pictures than control pictures. Similarly, Hermans et al. (1999) found that the initial attentional bias for spider stimuli in spider-fearful participants gave way to subsequent increased avoidance when compared to non-fearful controls (see also Pflugshaupt et al., in press; Rohner, 2002).

However, none of these studies address how attentional allocation changes as a threat's proximity increases. Given that, according to the models reviewed earlier (e.g. Fanselow, 1994; Lang et al., 1997), perceived proximity plays an important role in determining the type of defensive behaviour elicited by a threatening stimulus, this is an important question. The aim of this study is to examine how attention is initially allocated towards threatening stimuli as perceived proximity is manipulated. This study used a modified version of the visual probe task (MacLeod, Mathews & Tata, 1986) in which the spider and control pictures were presented for 200 ms. This stimulus duration was used as it has been found to be sensitive to attentional bias for spider pictures in spider-fearful individuals (Mogg & Bradley, in press). The visual probe task allows for the direction of attention at a given time to be measured. The stimuli used in this study were pairs of proximally and distally perceived spider and rabbit pictures. Perceived proximity was manipulated by using two different sizes of stimuli, and presenting them to participants with distance and depth cues masked. The aim was for the larger stimuli to be perceived to be closer than the smaller stimuli and, in the case of the spider stimuli, of greater threat intensity to the spider-fearful group. This was assessed by subjective rating tasks measuring perceived proximity and threat ratings for all the stimuli. The direction of attentional allocation was assessed from the reaction times (RTs) to the probes which appeared in the location of the different stimulus types.

In line with the various models of fear and anxiety (e.g. Fanselow, 1994; Lang et al., 1997) it was predicted that as perceived proximity increases the attentional bias may reduce. Predictions generated from cognitive models of anxiety (e.g. Mogg &

Bradley, 1998; Mathews & Mackintosh, 1998) suggest that, as perceived proximity increases, the initial attentional bias would intensify.

Method

Participants

Forty participants were recruited from undergraduates and graduates at the University of Southampton. Potential participants filled out an initial screening questionnaire of a single question asking how anxious they felt when looking at pictures of spiders. They were asked to respond on a scale of 0 (not at all anxious) to 9 (extremely anxious). The Low Fear Group (LFG; $n = 20$) had a response of 1 or less. The High Fear Group (HFG; $n = 20$) had a response of 6 or more.

Materials and Apparatus

The stimuli for the visual probe task consisted of 16 pairs of greyscale photographs of spiders and rabbits. These pictures came in two perceived proximity conditions; each was presented once as a proximal stimulus and once as a distal stimulus (see *Appendix One* for examples). Therefore, there were a total of 32 pairs. The pictures measured 12 cm by 12 cm when presented on the screen; in the proximal stimuli the rabbit/spider took up about 100% of the picture area and in the distal stimuli the rabbit/spider took up about 11% of the picture area. As the participants were seated 83 cm from the computer monitor, the proximally perceived pictures appeared to be approximately nine times larger than the distal ones. The proximal stimuli subtended 8.2° of visual angle and the distal stimuli subtended 2.7° of visual angle. During the visual probe task the pictures were presented side by side with a distance of 5.8 cm (approximately 4° of visual angle) between the inside edges. The same stimuli were used for the perceived proximity and threat rating tasks, in which they were individually presented. In these tasks, the pictorial stimuli were presented in the centre of the screen. The visual probe task also involved practice, buffer and filler trials. The stimuli for these were four pairs of greyscale cat and hamster pictures. These were presented both in proximal and distal perceived proximities, making a total of eight pairs of stimuli.

The computer tasks were presented in a dark, electrically isolated and soundproofed room. The pictorial stimuli for all experimental tasks were presented on a Viglen Pentium 120 PC with a 17-inch monitor, using MEL software. A Viglen DFK2020UK keyboard was used for recording responses in the visual probe task (this keyboard has low timing error for RTs; Mogg & Bradley, 1995). Additionally, participants looked at the monitor down a black rectangular tunnel constructed in order to mask distance and depth cues. This was used in order to enhance the perceived proximity manipulation. It also ensured that the participants were seated 83 cm from the monitor.

Procedure

Participants first completed a consent form. The tasks were presented in a fixed order for each participant, first the visual probe task, followed by the threat rating task and the perceived proximity rating task.

Each trial of the visual probe task started with a central fixation cross displayed for 500 ms, which was replaced by a pair of pictures, side by side, for 200 ms. Immediately after picture pair offset, a probe (a 5 mm arrow pointing either up or down) appeared in one of the previous picture positions, and was presented for a maximum of 10 s. Participants were asked to press one of two response buttons as quickly as possible to indicate whether the probe was oriented up or down. They were also instructed to keep looking at the screen throughout the task. To begin, participants were given eight practice trials, consisting of the filler picture pairs, before the start of the main task. The main task consisted of two buffer trials, 32 filler trials and 64 experimental trials, presented in a new random order for each participant. The 64 experimental trials consisted of the 16 proximal spider-rabbit pairs and the 16 distal spider-rabbit pairs. Each pair was shown twice, counterbalanced for the side of the spider picture and for the orientation of the probe. The 32 cat-hamster filler trials were interspersed randomly throughout the main task, and were used to ensure a spider did not appear in every trial. Half of the filler pairs were presented proximally and half distally.

After the visual probe task, participants completed a threat rating task and a perceived proximity rating task. The threat rating task consisted of 64 trials in which each spider and rabbit picture was presented individually in a new random order for each participant. The picture was presented in the centre of the screen and underneath it appeared a 7-point anchored rating scale. Each picture remained on screen until the participant responded, and then it was replaced by the next picture, with a 10 s inter-trial interval. The rating scale ranged from 1 (not at all threatening) to 7 (very threatening) and participants were asked to press one of keys to indicate how threatening they found each picture ("How threatening do you find this picture"). The perceived proximity rating task was identical except the rating scale ranged from 1 (very close) to 7 (very far away), and participants were asked to press one of seven keys to indicate how close or far away they thought the animal in each picture was ("How close or far away do you think the animal in this picture is?").

Upon completion of these computer tasks, participants completed the Spider Phobia Questionnaire (SPQ; Watts and Sharrock, 1984). This was done in order to check the grouping of participants into the fear groups which was initially done on the basis of a singly screening questionnaire. Finally, the participants were debriefed.

Results

Group Characteristics

The HFG had significantly higher scores on the SPQ, compared with the LFG (see Table 2.1 for means and *t*-test results).

Table 2.1 Fear Group Characteristics

	HFG		LFG			
	M	*SD*	*M*	*SD*	*t*	*p*
SPQ	15.56	4.16	4.95	2.84	9.51	< .001
Age (years)	20.20	2.12	21.30	6.16	0.76	*ns*
Gender ratio, m/f	5/15		6/14			

Visual Probe Task: manual RTs to probes

Overall, participants showed a significant attentional bias for the more distal spider pictures, relative to pictures of rabbits. There was no significant attentional bias for the more proximal spider pictures in either fear group.

One participant was excluded from this analysis due to interruption during the task, so there were 19 participants in the HFG and 20 in the LFG. RT data from trials with errors (3%) were discarded. RTs more than 3 *SD*s[2] (Mathews, May, Mogg & Eysenck, 1990) above the mean were excluded as outliers (1.3%), see Table 2.2 for means. Kolmogorov-Smirnov tests showed that the distribution of the data did not differ significantly from normal. RTs were entered into an analysis of variance (ANOVA) with fear group (high vs. low) as between-subjects independent variables and picture type (i.e. the picture which the probe replaces, spider vs. rabbit) and perceived proximity (proximal vs. distal) as within-subjects independent variables. The results showed a main effect of perceived proximity, $F(1, 37) = 19.03, p < .001$, and a main effect of picture type, $F(1, 37) = 10.00, p < .01$. The predicted fear group x picture type x perceived proximity interaction was not significant, $F(1, 37) = 1.60$, *ns*. There was however a significant perceived proximity x picture type interaction, $F(1, 37) = 12.40, p < .001$.

In order to explore the nature of this interaction, attentional bias scores were calculated for each participant. The attentional bias score = (the mean RT when the probe replaces the rabbit picture) – (the mean RT when the probe replaces the spider pictures). Positive scores, therefore, reflect an attentional bias towards the spider pictures relative to rabbit pictures, and negative scores reflect an avoidance of the spider pictures relative to rabbit pictures. Post hoc tests showed that the attentional bias in all participants for the distal spiders was significantly greater than 0 ($t(38) = 3.93, p < .001$), but that the bias scores in all participants for the proximal spiders were not significantly different from 0 ($t(38) = 0.31$, *ns*), see Figure 2.1.

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[2] The same pattern of results is observed when using a 2000 ms upper cut rather than an *SD* cut-off.

Table 2.2 Visual probe task mean RTs (ms) and bias scores

	HFG		LFG	
	M	*SD*	*M*	*SD*
Picture type	RTs to probe (ms)			
Proximal Spider	627.64	39.21	628.18	83.70
Proximal Rabbit	622.71	42.82	635.12	75.71
Distal Spider	602.48	37.36	601.67	84.72
Distal Rabbit	627.43	46.95	622.69	79.15
	Bias scores			
Proximal Spider	-4.93	20.91	6.94	24.63
Distal Spider	24.95	32.81	21.02	40.29

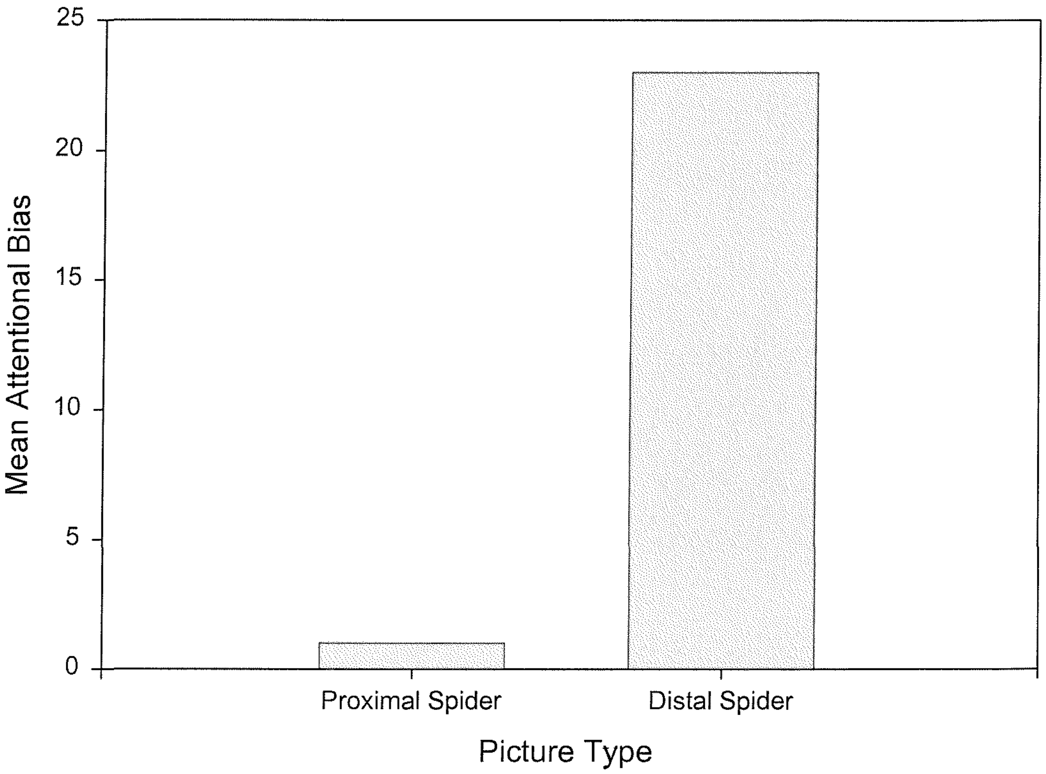

Figure 2.1 Mean Attentional Bias Scores for all participants

Perceived Proximity Rating Task

Overall, participants rated the proximal pictures, in both the spider and rabbit conditions, as being perceived to be closer than the distal pictures.

The subjective perceived proximity rating data were entered into a mixed design ANOVA with one between-subjects factor of fear group (high vs. low) and two within-subjects factors of picture type (spider vs. rabbit) and perceived proximity (proximal vs. distal); see Table 2.3 for means. Kolmogorov-Smirnov tests showed that the data did not differ significantly from normal. The results showed significant main effects of perceived proximity, $F(1, 38) = 271.16, p < .001$, and picture type, $F(1, 38) = 26.62, p < .001$. These were subsumed within a significant perceived proximity x picture type interaction, $F(1, 38) = 9.41, p < .01$. Post-hoc tests showed that the manipulation of perceived proximity was effective for each stimulus type; in general, participants found the proximal spiders to be closer than the distal spiders ($t(39) = 13.61, p < .001$), and the proximal rabbits to be closer than the distal rabbits ($t(39) = 17.04, p < .001$)[3], although the interaction indicates that this difference was somewhat larger for the rabbit stimuli.

Threat Rating Task

Participants in the high fear group rated both the proximal and distal spider pictures as being more threatening than participants in the low fear group. The proximal spider pictures were also rated as significantly more threatening than the distal spider pictures by participants, with no difference between the threat ratings of the proximal and distal rabbits.

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[3] These significant values remain so when using a Bonferroni correction which lowers the significance to the .0125 level.

The threat rating data were entered into a mixed design ANOVA with one between-subjects factor of fear group (high vs. low) and two within-subjects factors of picture type (spider vs. rabbit) and perceived proximity (proximal vs. distal); see Table 2.3 for means. Kolmogorov-Smirnov tests showed that the distribution of the means did not differ significantly from normal. The results showed main effects of fear group, $F(1, 38) = 13.27, p < .01$, picture type, $F(1, 38) = 297.96, p < .001$, and perceived proximity, $F(1, 38) = 104.05, p < .001$. There were also significant fear group x picture type interaction, $F(1, 38) = 15.48, p < .001$, and picture type x perceived proximity interaction, $F(1, 38) = 141.52, p < .001$.

Post hoc tests showed that the HFG found the spider pictures more threatening than the LFG ($t(38) = 3.92, p < .001$), with no difference between the groups in their threat ratings of the rabbit pictures ($t(38) = 0.39$, *ns*). In general, participants found the proximal spiders more threatening than the distal spiders ($t(39) = 11.51, p < .001$), with no difference between the threat ratings of the proximal and distal rabbits ($t(39) = 1.49$, *ns*)[4].

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[4] Again, these significant results remained so when using a Bonferroni correction.

Table 2.3 Rating Task Means

Picture Type	HFG		LFG	
	M	*SD*	*M*	*SD*
	Perceived Proximity Rating task			
Proximal Spider	2.12	0.79	2.28	0.69
Proximal Rabbit	2.90	1.12	2.70	0.78
Distal Spider	4.30	1.09	4.43	1.08
Distal Rabbit	5.60	0.81	5.07	0.96
	Threat Rating Task			
Proximal Spider	6.15	0.88	4.61	1.73
Proximal Rabbit	1.28	0.26	1.21	0.55
Distal Spider	4.87	1.16	3.15	1.56
Distal Rabbit	1.20	0.31	1.18	0.38

Correlations

Correlations were calculated between the SPQ[5] and the other measures for the whole sample. Increased SPQ scores were associated with greater threat ratings of proximal, $r(40) = .64, p < .001$, and distal spiders, $r(40) = .68, p < .001$.

Discussion

The results of the visual probe task indicate that participants, regardless of fear group, demonstrated an attentional bias for the spiders in the distal condition, relative to the rabbit pictures. The models discussed earlier propose that the threat value of

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[5] A Kolmogorov-Smirnov test showed the distribution of SPQ scores not to differ significantly from normal.

different stimuli leads to differences in attentional allocation. However, the spider-fearful group did not differ in their attentional allocation from the low spider-fearful group, even though the rating task indicates that the two fear groups' perception of the amount of threat the spider stimuli elicit does differ. In contrast, there have been countless empirical studies, using a variety of paradigms, which have shown that fear-relevant stimuli do affect attentional allocation between fear groups (see Mogg & Bradley, 1998 for a review). For example, Mogg and Bradley (in press) found an attentional bias for spider pictures in highly fearful participants using a visual probe task with a 200 ms SOA.

However, there were several issues which may help clarify the lack of a difference in attentional allocation between fear groups in the present study. First, is the question of whether the two groups were sufficiently well differentiated in fear level. For example, a possible concern is that the low fear group may not have had sufficiently low levels of fear. Although there is a significant difference between the threat ratings of the spider pictures between the two groups, the threat ratings of the low fear group for the proximal spiders are still quite high ($M = 4.61$). In order to examine this issue, the analysis was re-run using a double gating procedure. Participants were selected for the high fear group who were allocated into the high group by doing a median split on their scores on the screening questionnaire, the SPQ at test, and on their ratings of the spider pictures in the threat rating task (n = 15). Similarly, participants were selected for the low fear group who were allocated into the low group by a median split on their scores on the screening questionnaire, the SPQ at test, and on their ratings of the spider pictures in the threat rating task (n = 15). However, using the participants who fit these requirements, the results of the analysis remained the same. The significant main effects of perceived proximity ($F(1, 28) =$

21.69, $p < .001$) and picture type ($F(1, 28) = 4.25$, $p < .05$) remained, as did the significant picture type x perceived proximity interaction ($F(1, 28) = 12.58$, $p < 0.01$). However, the fear group x picture type x perceived proximity interaction ($F < 1$) remained non-significant. A similar analysis only used participants in the high fear group based on a median split on SPQ scores and who gave the spider pictures a threat rating of 4 or more (n = 18) and participants in the low fear group based on a median split on SPQ scores and who gave the spider pictures a threat rating of 4 or less (n = 10). Again the results of the ANOVA remained unchanged, with significant main effects of perceived proximity ($F(1, 26) = 8.96$, $p < .01$) and picture type ($F(1, 26) = 6.23$, $p < .05$), a significant picture type x perceived proximity interaction ($F(1, 26) = 8.26$, $p < 0.01$), and a non-significant fear group x picture type x perceived proximity interaction ($F(1, 26) = 1.85$, *ns*).

It is also the case that some studies have not found group differences in measures of initial attentional bias for threat. For example, studies by both Rohner (2002) and Hermans et al. (1999) did not find differences in the direction of the initial eye movements between groups who differed in spider fear (Hermans et al., 1999) and trait anxiety (Rohner, 2002). It was not until later on in the viewing time that the differences between the groups emerged. Therefore, it may be helpful for future research to include additional stimulus durations to obtain a larger sample of attentional bias scores over time. Indeed, the following study includes a visual probe task with two different stimulus duration times.

The two subjective ratings tasks indicate that the size manipulation of the stimuli was successful in altering participants' perception of proximity and threat value. In general, participants found the proximal pictures to be closer than the distal ones, for both the spider and the rabbit stimuli. The perceived proximity of the stimuli also affected how participants evaluated their threat value. Overall, participants rated the spiders in the proximal condition to be more threatening than the spiders in the distal condition. The threat rating task also demonstrated that spider-fearful participants rated all the spider stimuli as being more threatening than the LFG, with no difference between the groups in their threat ratings of the rabbit stimuli.

The perceived proximity manipulation seemed to be effective, as participants rated the proximal stimuli as appearing to be nearer, and the proximal spiders as appearing to be more threatening, than the distal ones. However, it may be noted that the quality of the pictures was limited (e.g. greyscale). Thus, in the next study a new set of pictures was selected and prepared using higher quality graphics with the aim of improving their ability to elicit emotional responses.

To summarise, the results of this study indicate that participants have an attentional bias for the spider stimuli in the distal condition. The following studies present more successful attempts to examine how the perceived proximity of a threat affects what kind of behaviour it elicits.

Chapter Three: Study 2: The Physiological Responses Elicited by Distally and Proximally Perceived Stimuli in Spider Fear

Abstract

The aims of this study were to examine the effects of perceived proximity on the physiological responses and attentional allocation to threat in spider fear. This was done by monitoring startle eye blink responses and skin conductance responses (SCR) to pictures of distally and proximally perceived spider and rabbit pictures. A visual probe task was also administered in order to assess attentional allocation to pairs of the distally and proximally perceived spider and rabbit pictures. The results showed that participants with a high fear of spiders demonstrated a potentiated startle response whilst viewing the spider in the proximal condition, compared with the low fear group. These participants also demonstrated enhanced SCR whilst viewing the spiders in both conditions of perceived proximity, compared to the low fear group. The results of the visual probe task did not show a difference between the two fear groups in their attentional responses to the spider pictures, even though they did rate the threat value of the spider stimuli differently.

Introduction

The main aim of this study is to examine the effect of perceived proximity on the physiological responses to threat. A secondary aim was to examine the effect of perceived proximity on attentional responses to threat. According to several models, discussed in the previous chapters, the outputs of the defence system, elicited in response to a threatening stimulus, can be divided into two distinct classes (e.g. Blanchard & Blanchard, 1988; Fanselow, 1994; Lang, Bradley & Cuthbert, 1997; McNaughton & Gray, 2000). These models suggest that the class of defence behaviour elicited in response to a threatening stimulus depends on the proximity and intensity of that threatening stimulus, as perceived by the individual. In particular, distal threatening stimuli elicit orienting and attentional processing, which allows the individual to assess the risk of the situation. However, more proximal threatening stimuli elicit the active defence behaviours, such as fight-or-flight.

As has been discussed in detail in *Chapter One*, Lang et al. (1997) have used these distinctions to describe human responses to threatening stimuli. They put forward the defence cascade model, which predicts that the amplitude of various physiological measures depends on the intensity of the threat. Making reference to some of the work cited above (e.g. Blanchard & Blanchard, 1988; Fanselow, 1994), this model predicts that distal, low intensity threat responses are associated with orienting responses, which include an inhibition of the startle reflex, a premature defence reflex (Bradley et al., 1999) and moderate skin conductance responses (SCR). However, proximal, high intensity threat leads to a potentiation of the startle reflex and greater SCRs.

There have been a great number of empirical studies examining the physiological responses to threatening stimuli (e.g. Bradley, Cuthbert, & Lang, 1990;

de Jong, Arntz, & Merckelbach, 1993; Hamm, Cuthbert, Globisch, & Vaitl, 1997; Hamm, Greenwald, Bradley, & Lang, 1993; Vrana et al., 1988; Yartz & Hawk, 2002). In general, these studies demonstrate that the magnitude of the startle reflex and SCRs are greater when elicited whilst participants view pictures of negative, threatening, aversive or fear-related stimuli. However, these studies do not address the issue of how these responses are affected by an increase in threat proximity or intensity. As was discussed in *Chapter One*, Bradley, Codispoti, Cuthbert and Lang (2001) carried out a study looking at physiological responses elicited by different types of threat stimuli. They recorded startle eye blink magnitudes and SCRs, and found that the most aversive and arousing pictures (e.g. of violent attack or mutilation) resulted in the largest SCR and elicited the greatest startle eye blink magnitudes in response to acoustic startle probes. However, less aversive, negative slides (e.g. of pollution or loss) elicited only moderate SCRs and no startle eye blink potentiation. These findings provide some support for the distinctions made by the models based on animal research (e.g. Fanselow, 1994), in particular those of the defence cascade model (Lang et al., 1997), that active defensive behaviours are elicited by high intensity threat stimuli, whereas low intensity threat elicits an orienting response.

Other studies investigating the effect of threat intensity on response have concentrated on attentional allocation. For example, Mogg et al. (2000) and Wilson and MacLeod (2003) conducted studies which examined the effect of manipulation of the intensity of a threat stimulus on attentional processing. These studies are discussed in greater detail in previous chapters, but their results indicate that increasing the intensity of threat leads to an increase in initial allocation of attention.

There has also been evidence to suggest that the initial attentional bias for threat, proposed by recent cognitive models of anxiety (e.g. Mogg & Bradley, 1998;

Mathews & Mackintosh, 1998), can be overridden by avoidance of threat in certain circumstances. For example, Tolin, Lohr, Lee and Sawchuk (1999) found that highly spider-fearful participants spend less time viewing spider pictures than control pictures. Also, Hermans, Vansteenwegen, and Eelen (1999) found that highly spider-fearful participants, after initial orienting, were more likely to avoid spider pictures than non-fearful controls (see also Pflugshaupt et al., in press; Rohner, 2002). Several models coming from a cognitive perspective have offered suggestions as to why in some circumstances initial vigilance for threat is replaced by avoidance. Öhman's (1996) model suggests that attention is automatically captured by innate fear stimuli because of our evolved defence system which allows for the rapid identification of threat (e.g. Öhman, Flykt & Esteves, 2001; Öhman, Lundqvist & Esteves, 2001; Öhman & Mineka, 2001). As the primary function of such a system is to ensure survival, then the rapid identification of a threat would lead to the activation of escape responses. Mogg and Bradley's (1998) model incorporates the vigilance-avoidance hypothesis. This suggests that the initial vigilance for threatening stimuli may be lost when stimuli are sufficiently threatening. The maintenance of attention to threat stimuli may be overridden by response tendencies to avoid the threat. For example, in order to reduce subjective discomfort an individual may avert their eyes from a fear-relevant scene.

The main aims of this study are to examine the effects of increasing perceived proximity on the physiological responses in high and low spider-fearful participants. A secondary aim was to examine the effect of perceived proximity on initial and maintained attentional allocation. Given that, according to the various models discussed, perceived proximity is crucial in determining the type of defensive behaviour elicited in response to a threatening stimulus, this is an important issue.

Physiological responses will be assessed by recording the startle eye blink magnitudes to acoustic startle probes and SCRs elicited whilst participants view the stimuli. The startle probes will be presented to participants either 300 ms or 3000 ms into the viewing time of the various stimuli. These two probe times will be used in order to examine initial and subsequent responses to the pictorial stimuli. For example, a study by Globisch et al. (1999) found that snake and spider fearful participants demonstrated a potentiated startle response to their feared stimuli as early as 300 ms into the viewing time. The secondary question of attentional allocation will be assessed by recording response time to probes in a modified visual probe task. This task will also use two stimulus durations in order to examine a larger portion of the time course of the attentional bias than in Study 1.

The stimuli used in this study were pairs of proximally and distally perceived spider and rabbit (control) pictures. Perceived proximity was manipulated by using different sizes of stimuli and presenting them to participants with distance and depth cues masked. The aim was for the larger stimuli to be perceived to be closer than the smaller stimuli, and, in the case of the spider stimuli, of greater threat intensity to the spider-fearful group. This was assessed by subjective rating tasks measuring perceived proximity and perceived anxiety ratings for all the stimuli. The stimuli used are similar to those used in the previous chapter, but are colour rather than greyscale.

In accordance with the predictions from the models based on animal behaviour (e.g. Fanselow, 1994; Lang et al., 1997), it is hypothesised that an increase in the perceived proximity of the spider stimuli will lead to an increase in physiological responses (i.e. startle and SCR) and a decrease in attentional allocation in the high fear group, compared to the low fear group and relative to the rabbit stimuli. Other theoretical models (e.g. Mogg & Bradley, 1998) suggest that highly threatening stimuli are more likely to elicit initial orienting which may be followed by avoidance. This suggests that an increase in proximity of the spider stimuli will elicit an increased attentional bias in the spider-fearful participants compared to the low spider-fearful participants and relative to the rabbit stimuli, which may subsequently give way to avoidance.

Method

Participants

Thirty-five participants were recruited from undergraduates and graduates at the University of Southampton. Potential participants filled out an initial screening questionnaire measuring how anxious they felt when looking at pictures of spiders. They were asked to respond on a scale of 0 (not at all anxious) to 9 (extremely anxious). The Low Fear Group (LFG; $n = 17$) had a response of 1 or less. The High Fear Group (HFG; $n = 18$) had a response of 6 or more.

Materials and Apparatus

Psychophysiological recording task. In the psychophysiological recording task individually presented colour pictures were used. These consisted of 16 colour spider pictures and 16 colour rabbit pictures. These pictures came in two perceived proximity conditions, each was presented once as a proximal stimulus and once as a distal stimulus (see *Appendix One* for examples). The pictures measured 12 cm by 12 cm; in the proximal stimuli the rabbit/spider took up about 100% of the picture area and in the distal stimuli the rabbit/spider took up about 11% of the picture area. As the participants were seated 83 cm from the computer monitor, the proximally perceived pictures appeared to be approximately nine times larger than the distal ones. The proximal stimuli subtended 8.2° of visual angle and the distal stimuli subtended 2.7° of visual angle. Therefore there were 64 individual stimuli presented during the psychophysiological recording task.

An acoustic startle stimulus was also used during the psychophysiological recording task. This was a 50 ms burst of 95-dB(A) white noise with a nearly instantaneous rise/fall time. It was generated by a white noise generator, gated by script program running by Spike2 (r) program (Cambridge Electronic Design) and presented binaurally through Sony DR-3A headphones. The startle stimulus was presented either 300 ms or 3000 ms into the viewing time of the stimuli.

During the psychophysiological recording task the stimuli presentation and physiological recording was controlled by two PC/AT-class microcomputers running special software packages. The visual stimuli sequence, their durations, and inter-trial intervals were controlled by a computer running Inquisit version 1.32 software. This computer also managed the startle probe presentation. Another computer, running Spike2 version 3.17 software, controlled the physiological recording.

The eye blink startle response was measured electromyographically from the orbicularis oculi using two miniature EL254S Ag/AgCl surface electrodes (Biopac System, Inc). These were filled with Biopac electrode gel and centred approximately 0.8 cm below the pupil and outer canthus of the left eye. One electrode was placed under the pupil of the left eye and the second was placed laterally at a distance of approximately 1 cm, edge to edge. A ground electrode was attached to the participant's left forearm. The EMG signals were amplified by CED 1902 bio-amplifiers. Amplifier output was fed to the Power 1401 A/D converter (CED, Cambridge Electronic Design Limited, UK) under control of Spike2 (Cambridge

Electronic Design Limited, UK) program interface installed in a PC/AT-compatible computer, which sampled the amplified EMG at 1000 Hz.

Skin conductance was recorded using two domed Ag/AgCl electrodes filled with a 0.05-M NaCl electrolyte. These electrodes were placed on the distal phalanges of the index and second fingers of the left hand. A constant voltage of 0.5 V was applied across the electrodes and skin conductance was measured using a CED preamplifier and sampled at 20 Hz.

Visual probe task. The 64 stimuli (32 in the proximal condition and 32 in the distal condition) used in the visual probe task were the same as those used in the psychophysiological recording task. However, each spider picture was paired with a rabbit picture of the same perceived proximity and matched for colour. Each picture pair was shown twice with a 300 ms SOA and twice with a 3000 ms SOA, making 128 critical paired presentations. The pictures were presented side by side with a distance of 5.8 cm (4° of visual angle) between the inside edges.

Threat and perceived proximity rating task. The stimuli used for the two rating tasks were identical to the individually presented stimuli used during the psychophysiological recording task.

Both the psychophysiological recording task and the visual probe task involved practice stimuli. These were 16 cat and 16 hamster colour pictures. These were presented both in proximal and distal perceived proximity conditions, making a total of 64 stimuli. Ten of these stimuli, five cat and five hamster, were presented individually as practice and buffer trials during the psychophysiological recording task. They were paired together to make practice, buffer, and filler trials for the visual probe task.

All the computer tasks were presented in a dark, electrically isolated and sound-proof room. The pictorial stimuli were presented on a Viglen Pentium 120 PC with a 17-inch monitor in indexed 256 colour palette, using Inquisit version 1.32 software. A Viglen DFK2020UK keyboard was used for recording responses in the visual probe task (this keyboard has low timing error for RTs; Mogg & Bradley, 1995). Additionally, participants looked at the monitor down a black rectangular tunnel constructed in order to mask distance and depth cues. This was used in order to aid the manipulation of perceived proximity. It also ensured that all participants were seated 83 cm from the monitor.

Procedure

Participants first completed a consent form. They were then seated, the electrodes were attached, and they were asked to put on the headphones. The tasks were presented in a fixed order for each participant, first the psychophysiological recording task, followed by the visual probe task, then the threat and perceived proximity rating tasks. The psychophysiological recording task was first in order to ensure that habituation to the stimuli did not occur so as to maximise the measures (SCR in particular have been found to diminish rapidly with repeated picture presentation, (Bradley, Lang & Cuthbert, 1993)).

The psychophysiological recording task commenced with five-minute rest period during which non-specific SCR and eye blink responses were monitored. Participants were asked to relax with their eyes open during this period. After this participants were presented with six startle probes, presented one after the other with

12 s between them, so that physiological signals could be checked. The participants were instructed that they would see a series of pictures, that each picture should be viewed for the entire time it is displayed and that any acoustic stimuli should be ignored. Before the main block, the participants saw a set of eight practice pictures and two buffer pictures with either no startle probe, a 300 ms startle probe or a 3000 ms startle probe. The main experimental block was then presented. This consisted of the 64 individual stimuli, presented in a mixed random order for each participant, for 6s. Randomised inter-trial intervals (ITIs) ranged from 9 s to 15 s (with a mean of 12 s) with experimenter initiation of each subsequent trial, which varied between subjects. Trials were not initiated when the subject was moving or showed signs of increasing SCR. For the individually presented pictures, 24 were presented with a 300 ms startle probe, 24 were presented with a 3000 ms startle probe, and 16 were presented with no startle probe. Each of these 24 consisted of six proximal spiders, six distal spiders, six proximal rabbits and six distal rabbits. Likewise, the 16 pictures presented with no startle probe consisted of four proximal spiders, four distal spiders, four proximal rabbits and four distal rabbits. Which particular stimulus was shown with each probe condition varied between participants. Sixteen of the ITIs also had startle probes, eight with 300 ms probes and eight with 3000 ms probes. This was done in order to reduce the predictability of the probes.

The visual probe task followed, once the electrodes had been removed from the participant. Each trial of the probe detection task started with a central fixation cross displayed for 500 ms, which was replaced by a pair of pictures, side by side, for either 300 ms or 3000 ms. These SOAs were used as they were the same as the acoustic probe times in the physiological recording task. These timings also allowed the assessment of initial orienting and maintained attention. Immediately after picture pair offset, a probe (a 5 mm arrow pointing either up or down) appeared in one of the previous picture positions, and was presented for a maximum of 10s. Participants were asked to press one of two response buttons as quickly as possible to indicate whether the probe was oriented up or down. They were also instructed to keep looking at the screen throughout the task. To begin, participants were given 10 practice trials, consisting of the filler picture pairs, before the start of the main task. The main task consisted of two buffer trials, 64 filler trials and 128 experimental trials. The 128 experimental trials consisted of 32 trials presenting proximal spider-rabbit picture pairs with a SOA of 300 ms, 32 proximal spider-rabbit picture pairs with a SOA of 3000 ms, 32 distal spider-rabbit picture pairs with a SOA of 300 ms and 32 distal spider-rabbit picture pairs with a SOA of 3000 ms. The 64 cat-hamster filler trials were used to ensure a spider did not appear in every trial. Half of the filler pairs were presented proximally and half distally, with half of each group shown at 300 ms and half at 3000 ms.

After the startle probe and the visual probe tasks, participants completed a threat rating task and a perceived proximity rating task, which were the same as those used in Study 1. The threat rating task consisted of 64 trials in which each spider and rabbit picture was presented individually in a new random order for each participant. The picture was presented in the centre of the screen and underneath it appeared a 7-point anchored rating scale. Each picture remained on screen until the participant responded, and then it was replaced by the next picture, after a 1000 ms inter-trial interval. The rating scale ranged from 1 (not at all threatening) to 7 (very threatening) and participants were asked to press one of keys to indicate how threatening they found each picture ("How threatening do you find this picture?"). The perceived proximity rating task was identical except the rating scale ranged from 1 (very close) to 7 (very far away), and participants were asked to press one of seven keys to indicated how close or far away they thought the animal in each picture was ("How close or far away do you think the animal in this picture is?").

Upon completion of these computer tasks, participants completed the Spider Phobia Questionnaire (SPQ; Watts and Sharrock, 1984) and were debriefed.

Data Reduction and Analysis

Using the Spike2 3.17 programme, the startle eye blink data of each participant was analysed offline. The digitised EMG activity of orbicularis oculi was subjected to a bandpass filter, with cut-off frequencies of 90 and 250 Hz (see Bradley et al., 2001). The data were then rectified and integrated using a constant of 20 ms (8 Hz). Measures of magnitude were derived from this integrated signal. The response peak for each trial was defined as the peak response between 21-150 ms after onset of the startle probe. The baseline magnitude for each trial was calculated as the mean measure of EMG activity of orbicularis oculi within the 150 ms before startle probe onset. The peak magnitude, in microvolts (μV), for each trial was calculated by subtracting the mean response from the peak response for that trial. All the trials were used in the analysis.

Using the Spike2 3.17 programme, the skin conductance responses (SCR) of each trial was analysed offline. Data were collected for 1s previous to picture presentation and for seconds 1 - 4 of picture presentation. Data were analysed only for trials without a startle probe and with the startle at 3000 ms (48 trials). The trials with a 300 ms startle were not used as it is not possible to distinguish the SCRs to the picture from those to the acoustic startle probe. Due to the lag time for SCR (typically more than 1s) the 3000ms startle probe would not influence SCR measurements for seconds 1 – 4. The magnitude of SCR for each trial was calculated by subtracting the mean SCR in the 1s prior to picture presentation from the peak SCR recorded during the picture presentation (Codispoti et al., 2001).

Results

Group Characteristics

The HFG had significantly higher scores on the SPQ compared with the LFG (see Table 3.1 for means and *t*-test results).

Table 3.1 Fear Group Characteristics

	HFG		LFG			
	M	*SD*	*M*	*SD*	*t*(33)	*p*
SPQ	17.22	5.15	3.94	2.08	9.89	< .001
Age (years)	22.44	3.96	23.71	4.01	0.94	*ns*
Gender, m/f	4/14		6/11			

Psychophysiological Data

The HFG showed greater startle eye blink responses to the proximal spiders, relative to the LFG. Participants in the HFG also exhibited greater magnitudes in SCR during all spider stimuli, compared to rabbit stimuli and relative to the LFG.

Startle eye blink response. The data from one HFG participant were lost due to equipment failure, so there are 17 participants in each group. The mean eye blink magnitude data are displayed in Table 3.2 below. Kolmogorov-Smirnov tests showed this data did not differ from the normal distribution. The data were entered into a mixed design analysis of variance (ANOVA) with one between-subjects factor of fear group (high vs. low) and three within-subjects factors of picture type (spider vs. rabbit), perceived proximity (proximal vs. distal), and lead time of startle probe (300 ms vs. 3000 ms). The results showed a main effect of perceived proximity, $F(1, 32) = 7.28, p < .05$, and fear group, $F(1, 32) = 4.30, p < .05$. These effects were subsumed under a significant fear group x picture type x perceived proximity interaction, $F(1, 32) = 8.43, p < .01$.

To explore this interaction, two further ANOVAs were performed. First an ANOVA for the proximal pictures alone, with one between-subjects factor of fear group (high vs. low) and one within-subjects factor of picture type (spider vs. rabbit). The results showed a significant main effect of fear group, $F(1, 32) = 4.99, p < .05$, and of picture type, $F(1, 32) = 4.19, p < .05$, which were subsumed within a significant fear group x picture type interaction, $F(1, 32)= 7.41, p < .05$. Post hoc tests showed that the HFG had larger startle responses to the proximal spiders than the LFG, $t(32) = 2.66, p < .025$[6], but there was no differences between the groups in their startle magnitudes to the proximal rabbits, $t(32) = 1.74$, *ns*, see Figure 3.1. An ANOVA carried out for the distal pictures alone showed no significant main effects or interactions.

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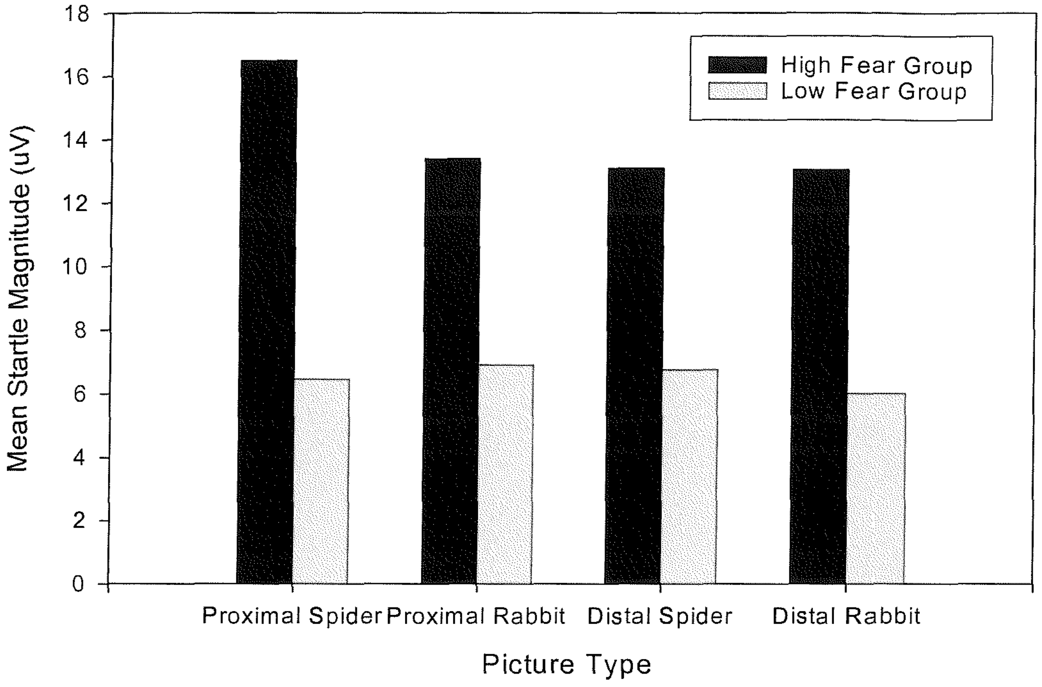
[6] This result is significant when using a Bonferroni adjustment ($p < .025$).

Table 3.2 Mean Startle eye blink magnitudes (uV)

	HFG		LFG	
Picture Type	*M*	*SD*	*M*	*SD*
Proximal Spider 300 ms startle	15.0	12.8	5.9	7.0
Proximal Spider 3000 ms startle	18.0	15.5	7.0	8.0
Proximal Rabbit 300 ms startle	13.4	12.5	6.4	8.1
Proximal Rabbit 3000 ms startle	13.4	13.8	7.4	9.0
Distal Spider 300 ms startle	12.0	10.2	7.0	8.3
Distal Spider 3000 ms startle	14.2	13.8	6.5	9.0
Distal Rabbit 300 ms startle	12.5	14.0	5.2	7.4
Distal Rabbit 3000 ms startle	13.6	13.7	6.8	7.4

Figure 3.1 Mean eye blink startle magnitudes (μv)



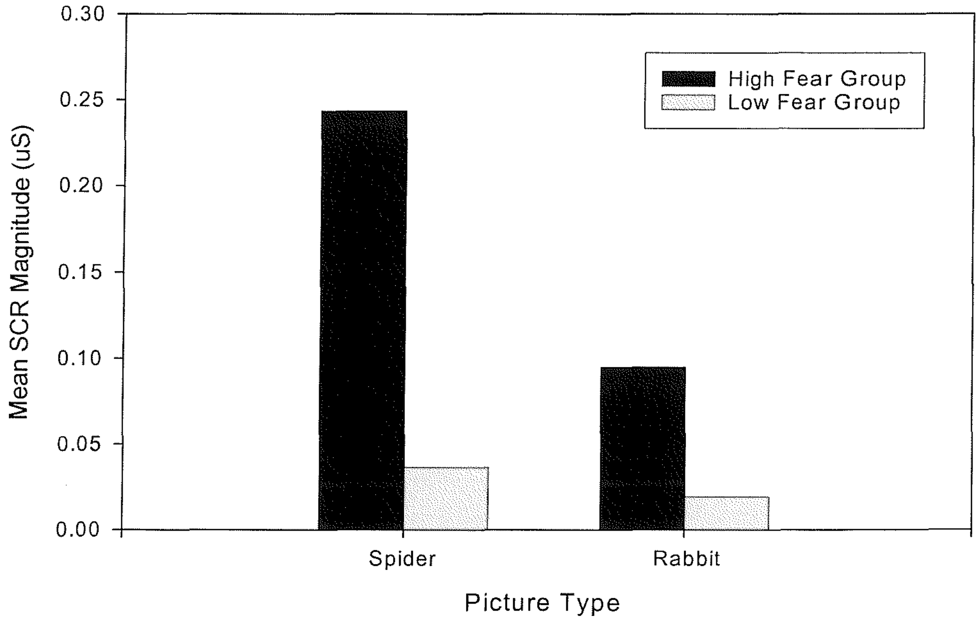
Skin conductance responses (SCR). The data from three participants were lost due to equipment failure, so there are 17 participants in the HFG and 15 in the LFG. The mean SCR data are displayed below in Table 3.3. The data were log transformed to normalise the distribution (see Bradley M. et al., 2001). The logged data were entered into an ANOVA with picture type (spider vs. rabbit) and perceived proximity (proximal vs. distal) as within-subjects factors and fear group (high vs. low) as a between-subjects factor. The results showed a main effect of fear group, $F(1, 30) = 7.32, p = .05$, and picture type, $F(1, 30) = 7.03, p < .05$. These were subsumed within a significant fear group x picture type interaction, $F(1, 30) = 4.17, p = .05$. Post hoc comparisons showed that the HFG had larger SCRs in response to spiders than the LFG ($t(30) = 2.61, p < .0125$), but that there was no difference between the groups in their SCRs to the rabbits, ($t(30) = 1.71$, *ns*). A paired *t*-test confirmed that the SCRs elicited by the spiders in the high fear group was significantly greater than those elicited by the rabbits, $t(16) = 2.595, p < .0125$. In the low fear group the SCR elicited by the spiders did not differ from the SCR elicited by the rabbits, $t(14) = 1.09$, *ns*; see Figure 3.2[7]. The predicted fear group x picture type x perceived proximity interaction was not significant, $F(1, 30) = 1.25$, *ns*.

Table 3.3 Mean SCR magnitudes (uS)

	HFG		LFG	
Picture Type	*M*	*SD*	*M*	*SD*
Proximal Spider	0.32	0.48	0.05	0.09
Proximal Rabbit	0.10	0.13	0.01	0.02
Distal Spider	0.16	0.13	0.02	0.05
Distal Rabbit	0.09	0.19	0.03	0.04

Note. The unit of measurement used for SCR is microSiemens (μS).

Figure 3.2 Mean SCR (μS)



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[7] These significant results remain so when using a Bonferroni adjustment ($p < .0125$).

Visual Probe Task: manual RTs to probes

Overall, participants showed a significant attentional bias for all spider pictures. Furthermore, participants were faster to respond to probes, regardless of which picture they replaced, when they followed distal picture pairs than when they replaced proximal picture pairs.

RT data from trials with errors (2.9%) were discarded. RTs more than 2 *SD*s above the mean were excluded as outliers (3.4% of data)[8], see Table 3.4 for means. Kolmogorov-Smirnov tests showed this data did not differ significantly from the normal distribution. The RTs were entered into an ANOVA with fear group (high vs. low) as a between-subjects independent variable and picture type (i.e. the picture the probe replaces, spider vs. rabbit), perceived proximity (proximal vs. distal), and stimulus duration (SOA) (300 ms vs. 3000 ms) as within-subjects independent variables. The results showed a main effect of picture type, $F(1,33) = 5.21, p < .05$, as RTs were significantly faster when the probes replaced spider pictures ($M = 576$ ms) than when they replaced rabbit pictures ($M = 596$ ms). There was also a main effect of perceived proximity, $F(1, 33) = 5.40, p < .05$, as participants, in general, had faster RTs to probes, regardless of which picture they replaced, when they replaced distal picture pairs ($M = 583$ ms) than when they replaced proximal picture pairs ($M = 589$ ms). The predicted fear group x picture type x perceived proximity interaction was not significant, $F < 1$.

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[8] The same pattern of results is observed when RTs more than 3 *SD*s above the mean are excluded and also when a 2000ms upper cut is used.

Table 3.4 Mean Visual probe task reaction times (ms)

Picture type	HFG		LFG	
	M	*SD*	*M*	*SD*
Proximal Spider	589.18	64.14	568.98	39.79
Proximal Rabbit	607.89	72.83	589.02	59.35
Distal Spider	583.64	60.50	561.79	39.52
Distal Rabbit	601.98	74.45	582.15	59.90

Perceived Proximity Rating Task

Overall, participants rated the proximal pictures as being perceived to be closer than the distal pictures.

The subjective perceived proximity rating data were entered into a mixed design ANOVA with one between-subjects factor of fear group (high vs. low) and two within-subjects factors of picture type (spider vs. rabbit) and perceived proximity (proximal vs. distal); see Table 3.5 for means. Kolmogorov-Smirnov tests showed the data distributions did not differ from normal. The results showed significant main effects of perceived proximity, $F(1, 33) = 32.04, p < .001$, and picture type, $F(1, 33) = 241.81, p < .001$. These were subsumed within a significant perceived proximity x picture type interaction, $F(1, 33) = 11.91, p < .001$. Post hoc tests showed that the manipulation of perceived proximity was effective for each stimulus type; overall, participants found the proximal spiders to be closer than the distal spiders ($t(35) = 13.75, p < .001$) and the proximal rabbits to be closer than the distal rabbits ($t(35) =$

15.60, $p < .001$)[9], although the interaction indicates that this difference is somewhat larger for the rabbit stimuli.

Threat Rating Task

Participants in the high fear group rated both the proximal and the distal spider pictures as being more threatening than participants in the low fear group.

The threat rating data were entered into a mixed design ANOVA with one between-subjects factor of fear group (high vs. low) and two within-subjects factors of picture type (spider vs. rabbit) and perceived proximity (proximal vs. distal); see Table 3.5 for means. Kolmogorov-Smirnov tests showed this data did not differ significantly from the normal distribution. The results showed main effects of fear group, $F(1, 33) = 120.63, p < .001$, picture type, $F(1, 33) = 180.19, p < .001$, and perceived proximity, $F(1, 33) = 24.29, p < .001$. There were also significant interactions of fear group x picture type, $F(1, 33) = 116.08, p < .001$, fear group x perceived proximity, $F(1, 33) = 6.02, p < .05$, and picture type x perceived proximity, $F(1, 33) = 45.96, p < .001$. These were subsumed within a significant fear group x picture type x perceived proximity interaction, $F(1, 33) = 11.66, p < .01$.

Two further ANOVAs were carried out to examine this interaction. First an ANOVA for the spider pictures alone, with fear group (high vs. low) and perceived proximity (spider vs. rabbit) as independent variables. The results showed a significant main effect of fear group, $F(1, 33)= 154.54, p < .001$, and of perceived proximity, $F(1, 33) = 49.02, p < .001$, and a significant fear group x perceived proximity interaction, $F(1, 33)= 12.23, p < .01$. Post hoc tests showed that the HFG rated both the proximal ($t(33) = 13.67, p < .001$) and distal spiders ($t(33) = 9.28, p <$

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[9] Again, these results remain significant with a Bonferroni adjusted significance at the .0125 level.

.001)[10] as more threatening than the LFG. The interaction indicates that this effect is somewhat larger for the proximal spiders. A similar ANOVA carried out for the rabbit pictures alone showed only a main effect of perceived proximity, $F(1, 33)= 5.44, p < .05$. In general all participants rated the proximal rabbit ($M = 1.42$) as more threatening than the distal rabbit ($M = 1.09$).

Table 3.5 Perceived Proximity and Threat Rating Means

Picture Type	HFG		LFG	
	M	*SD*	*M*	*SD*
	Perceived Proximity Rating Task			
Proximal Spider	1.31	0.30	1.76	0.83
Proximal Rabbit	2.03	0.91	2.50	1.16
Distal Spider	3.85	1.06	4.14	1.05
Distal Rabbit	5.27	0.83	5.09	0.71
	Threat Rating Task			
Proximal Spider	6.12	0.99	1.88	0.21
Proximal Rabbit	1.57	1.19	1.27	0.41
Distal Spider	4.70	1.38	1.40	0.12
Distal Rabbit	1.07	0.12	1.10	0.27

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[10] These results remain the same when using a Bonferroni adjustment.

Correlations

Correlations were calculated between the SPQ[11] and the other measures for the whole sample. Increased SPQ scores were associated with greater startle magnitudes elicited by proximal spiders, $r(34) = .34, p < .05$, and greater SCRs elicited by proximal spiders, $r(32) = .41, p < .05$. Increased SPQ are also associated with greater threat ratings of proximal spiders, $r(35) = .79, p < .001$, and distal spiders, $r(35) = .81$, $p < .001$. There were no significant correlations between the SPQ scores and the measures of attentional bias.

Other significant correlations between the other measures are as follows. Increased threat ratings of proximal spiders are associated with both greater startle magnitudes elicited by proximal spiders, $r(34) = .48, p < .01$, and greater SCRs elicited by proximal spiders, $r(32) = .42, p < .05$. Increased threat ratings of distal spider are also associated with greater startle magnitudes elicited by distal spiders, $r(34) = .39, p < .05$.

Discussion

The main aim of this study was to examine how physiological responses are affected by threatening stimuli of different perceived proximities. The secondary aim was to examine the effects of perceived proximity on attentional allocation. The results of the physiological recording task indicate that the magnitude of the startle reflex was affected by the perceived proximity of the threatening stimulus. Participants fearful of spiders demonstrated significantly larger startle eye blinks in response to auditory probes whilst viewing pictures of the proximal spiders, relative to rabbit pictures and compared to non-fearful participants. In addition to eliciting a

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[11] A Kolmogorov-Smirnov test showed that the distribution of SPQ scores did not differ significantly from the normal distribution.

potentiated startle response in the high fear group, the more proximally perceived spider stimuli elicited this response regardless of whether the probes occurred early (300 ms) or late (3000 ms) after picture onset. This suggests that a degree of defensive activation is being elicited by threat in the proximal condition, and that this defensive activation appears to be occurring rapidly and is sustained. The distally perceived threat does not elicit this defensive response. However, the magnitude of SCR did not seem affected by the perceived proximity of the threatening stimulus. HFG demonstrated greater magnitudes of SCR in response to the spider stimuli as a whole, regardless of perceived proximity condition, relative to rabbits and compared to the LFG.

The visual probe task was not successful in differentiating between the fear groups. In general, participants demonstrated an attentional bias for the spider stimuli, regardless of both perceived proximity and time of probe onset. A lack of group difference in attentional bias for spiders is inconsistent with several models (e.g. Öhman, 1996) and previous findings (e.g. Mogg & Bradley, in press). However, the visual probe task was administered after the physiological recording task, during which the participants had already been exposed to all the stimuli. The combination of previous exposure to all the stimuli and fatigue due to the length of the task may account for the lack of results. It may be helpful for future studies to try to assess psychophysiological and attentional responses concurrently, rather than sequentially. A fixed order was used in this study because the main aim was to examine the effect of perceived proximity on physiological responses. Given the theoretical importance of this question (e.g. Fanselow, 1994; Lang et al., 1997), this was of primary interest.

The subjective rating tasks indicated that manipulating the size of the stimuli has been successful in altering participants' perception of proximity and threat intensity. Overall, participants perceived the proximal pictures to be closer than the distal ones, for both the spider and rabbit stimuli. The perceived proximity of the stimuli also affected how threatening the high fear group perceive the spider stimuli to be. The spider-fearful participants found both the proximal and the distal spider pictures in general to be more threatening than the LFG, with the difference being greater for the proximal spiders.

The correlations between measures support the findings from the ANOVAs. Higher SPQ scores were associated with greater startle and SCR magnitudes when viewing spiders in the proximal condition. They were also associated with greater threat ratings of the spiders in the proximal condition. Higher ratings of threat given to the proximal spiders are in turn associated with greater startle and SCR magnitudes when viewing the proximal spiders.

Therefore, these results indicated that proximally perceived, highly threatening stimuli (i.e. the proximally perceived spider stimuli for the high fear group) elicit a rapid and sustained potentiated startle reflex. Threatening stimuli, regardless of perceived proximity (i.e. the spider stimuli for the high fear group), also elicit enhanced magnitudes of SCR.

The theoretical models based on animal research (e.g. Fanselow, 1988; Lang et al., 1997) divide the responses elicited by threatening stimuli into two broad categories depending of the proximity of the stimulus. Distal low-intensity threatening stimuli elicit attentional processing, whist proximal high-intensity threatening stimuli elicit active defence responses. This study provides partial support for this view; the proximally perceived spider stimuli elicited a potentiated startle reflex in the high fear group. The startle response itself is seen as a premature defence mechanism elicited in response to aversive stimuli (Lang et al., 1990; Bradley et al., 1999) – "clear evidence that the organism has changed to a defensive posture is first seen in the probe reflex response" (Lang et al., 1997, pg. 128).

In addition to the proximal stimuli eliciting this defensive response in the high fear group, the response appears to be a rapid one. The rapid processing of threat has been proposed by many (e.g. Öhman, 1997; Öhman & Mineka, 2001; LeDoux, 1996). Öhman and Mineka (2001) propose a fear module which has an automatic response that can recognise threatening stimuli and trigger a defence response without conscious awareness. Furthermore, LeDoux (1996) describes a pathway which would allow for a rapid transmission of threat related information from the thalamus to the amygdala. This would allow for the rapid response seen in the high fear group in their potentiated startle response to proximally perceived spiders, which occurred at both 300 ms and 3000 ms into the viewing time. Indeed, Globisch, Hamm, Esteves and Öhman (1999) found that snake and spider phobic participants demonstrated a potentiated startle response to probes presented 300 ms after the onset of fear-relevant stimuli. Merckelbach, de Jong, Leeuw and van den Hout (1995) also found some evidence of a potentiated startle response to masked spider pictures in spider phobics. However, the present study is unique in that the potentiated startle is only found for fear-relevant stimuli which are perceived to be proximal, and not for fear-relevant stimuli which appear to be distal.

In summary, the present study provides an assessment of the effect of perceived proximity of threat on the physiological indices of the startle response and SCR; and a less successful assessment of attentional allocation. The results indicated that participants with a fear of spiders demonstrate a potentiated startle response when viewing the proximal spider stimuli. The distal spider stimuli do not elicit this defensive response in the HFG. However, both distally and proximally perceived spider stimuli elicit increased magnitudes of SCR in the high fear group. This suggests perhaps that SCR operate on a lower threshold of threat than the startle reflex. These results provide some support for behavioural models which distinguish responses made to threatening stimuli into two categories based on their proximity (e.g. Lang et al., 1997; McNaughton & Gray, 2000). It also provides support for the idea that defence activation, as indexed by a potentiated startle response, can occur rapidly (e.g. Öhman and Mineka, 2001).

The following chapter will present an attempt to obtain concurrent measures of both physiological responses and attentional allocation to stimuli at proximal and distal perceived proximities in spider phobia. This will be done using a hybrid task which will measure eye movements as well as startle eye blink and skin conductance responses. Hopefully, these results will allow for a more comprehensive assessment of the effect of a threat's perceived proximity on attentional and physiological responses.

Chapter Four: Study 3: Attentional Allocation and Physiological Responses to Proximally and Distally Perceived Stimuli in Spider Fear – a Hybrid Design

Abstract

The aim of this study was to examine the effect of perceived proximity on the physiological responses and attentional allocation to threat. The study used a hybrid task in which individual and paired pictures of distally and proximally perceived rabbits and spiders were displayed. This enabled the monitoring of startle eye blink responses, skin conductance response (SCR), and eye movements (EM) within the same task. Participants were less likely to direct their gaze initially towards distal spiders than to proximal spiders. The high fear group showed a greater tendency than the low fear group to direct their gaze at spiders (relative to rabbits) and they also showed greater startle eye blink magnitudes and SCRs in response to the spider pictures (relative to rabbits). These effects were not significantly influenced by perceived proximity.

Introduction

In the previous two experimental chapters, studies have been reported which have attempted to examine the effect of a threat's perceived proximity on the allocation of attention and on the physiological responses it elicits. The aim of this study is to build on their results in the examination of this issue. This is important because various theoretical models (e.g. Blanchard & Blanchard, 1988; Fanselow, 199; Lang et al., 1997; McNaughton & Gray, 2000) emphasise the significance of the proximity of a threat in determining the type of defensive behaviour it will elicit. To recap, these models suggest a defence system which has two distinct levels, each associated with a different class of behaviour. The proximity of the threat, as perceived by the individual, helps to determine which level is activated. Distal threat stimuli elicit an inhibition of current behaviour as the individual focuses its attention on the threat. This allows for perceptual processing of the threat, reduces the chance of the individual's detection by it, and allows the animal to assess the risk of the situation. However, a more proximal threat leads to a loss of the perceptual processing in favour of active defence behaviours of escape or attack. In addition to these predictions concerning the allocation of attentional resources, Lang et al. (1997) have proposed the defence cascade model that predicts the physiological response which should occur in humans as a threat increases in intensity. For distal, low-intensity threat, responses associated with the orienting response are observed. These include an inhibition of the startle reflex and only moderate SCR. However, in response to more proximal, high-intensity threat, a potentiation of the startle reflex and increases in SCR should be observed.

Cognitive models of anxiety also make predictions concerning attentional allocation towards threatening stimuli (e.g. Williams et al., 1997; Mogg & Bradley, 1998; Mathews & Mackintosh, 1998). These models predict that threatening stimuli elicit an attentional bias in anxious individuals. They also predict that as the threat value of a stimulus increases, as it would do as it increases in proximity, the bias in the initial allocation of attention will only become more pronounced. Two studies, mentioned earlier, have found evidence to support this conclusion (Mogg et al., 2000; Wilson & MacLeod, 2003). There is also evidence that, in some circumstances, the attentional bias for threat gives way to avoidance (e.g. Tolin et al., 1999; Hermans et al., 1999; Rohner, 2002; Pflugshaupt et al., in press). This is predicted by Mogg and Bradley (1998) in their vigilance-avoidance hypothesis. Furthermore, Öhman (1996) proposed that our fear system is developed to ensure survival, and therefore has evolved to rapidly detect threat and then to avoid it.

However, none of these studies address how attentional allocation and physiological responses change as threat proximity increases. Previous studies in this thesis examining these different predictions have had mixed success. Study 1, which attempted to examine the effect of perceived proximity on initial orienting using a visual probe task, was unsuccessful as the results were largely non-significant (participants showed an attentional preference for distal rabbits than spiders, but there were no differences between the high and low fear groups). However, Study 2, which used a new set of colour stimuli, had greater success as it showed that the perceived proximity of a threat did have an effect on the magnitude of the startle response, with the spiders in the proximal condition eliciting a potentiated eye blink response in the spider-fearful group. However, it did not reveal attentional biases, which may have been due to the attentional task being administered after all participants had extensive exposure to the spiders and control stimuli. This may have caused habituation, or possibly strong priming, which may have obscured any individual differences associated with spider-fear. The present study utilises a hybrid design in an attempt to obtain concurrent measures of both physiological (startle eye blink and SCR) and attentional (eye movement) responses to the stimuli.

The same stimuli will be used in this study as were used in Study 2. Namely, proximally and distally perceived spider and rabbit colour pictures. As was done in the previous two studies, perceived proximity will be manipulated by using different sizes of stimuli and presenting them to the participants with distance and depth cues masked. Subjective rating tasks of perceived proximity, valence and arousal will assess whether this manipulation is successful in altering participants' perceptions of proximity and threat intensity. The previous two studies have examined the valence and arousal of the stimulus by asking about "how threatening" the pictures made the participant feel. In this study, the issue will be addressed slightly differently by looking at valence and emotional arousal separately. Lang et al. (1997) suggest that the measures of startle and SCR are thought to tap in respectively to these different dimensions. The stimuli were presented both in pairs, in order to measure eye movements, and individually, in order to measure eye blinks to acoustic startles and SCRs. This enabled both attentional and physiological responses to be assessed during a single task.

In accordance with the predictions from models based on animal research (e.g. Fanselow, 1994; Lang et al., 1997), it is hypothesised that an increase in the perceived proximity of the spider stimuli will lead to an increase in physiological responses (i.e. startle and SCR) and a decrease in attentional allocation in the high fear group, compared to the low fear group and relative to the rabbit stimuli. Predictions generated from cognitive models of anxiety (e.g. Mogg & Bradley, 1998) suggest that an increase in perceived proximity will lead to an increase in the initial attentional orienting towards the threat, which may then give way to active avoidance.

Method

Participants

Forty participants were recruited from undergraduates reading psychology at the University of Southampton. For this study, and for all the subsequent studies in this thesis, potential participants were screened using the Spider Phobia Questionnaire (SPQ; Watts & Sharrock, 1984). They were given it as part of a pack of questionnaires at the start of the academic year, and were then invited to participate in the studies as and when required. Selection criteria for participants were that they scored either 4 or less or 12 or more on the SPQ. Twenty participants were recruited into the low fear group (LFG) and 20 into the high fear group (HFG).

Materials and Apparatus

Psychophysiological recording task. There were two stimuli types (spiders and rabbits) and two trial types used during the psychophysiological recording task. The first trial type involved individually presented colour pictures. These consisted of 18 colour spider pictures and 18 colour rabbit pictures. These pictures came in 2 perceived proximity conditions; each was presented once as a proximal stimulus and once as a distal stimulus (see *Appendix One*). The pictures measured 12cm by 12cm; in the proximal condition the rabbit/spider took up about 100% of the picture area and in the distal condition the rabbit/spider took up about 11% of the picture area. As the participants were seated 83 cm from the computer monitor, the proximally perceived pictures appeared to be approximately nine times larger than the distal ones. The proximal stimuli subtended 8.2° of visual angle and the distal stimuli subtended 2.7° of visual angle. There were 72 individual stimuli presented. The second trial type involved 36 colour picture pairs of spider-rabbit stimuli. These pairs were made up of the same pictures as the individual stimuli, matched for perceived proximity and colour. They were presented on the computer monitor side by side, with 5.8cm (4° of visual angle) between their inside edges. Each pair was presented twice, counterbalanced for the side of the spider picture. Therefore, there were 72 paired stimuli presented. In addition to these stimuli, ten practice/buffer pictures were used. These were five individually presented pictures of cats or hamsters, two of which were proximal and three of which were distal. There were also five cat-hamster paired stimuli presented, two pairs of which were of proximal stimuli and three of which were distal stimuli.

An acoustic startle stimulus was used during the psychophysiological recording task. This was a 50 ms burst of 95-dB(A) white noise with a nearly instantaneous rise/fall time. It was generated by a white noise generator, gated by script program running by Spike2 (r) program (Cambridge Electronic Design) and presented binaurally through Sony DR-3A headphones.

During the psychophysiological recording task all stimuli presentation and physiological recording was controlled by two PC/AT-class microcomputers running special software packages. The visual stimuli sequence, their durations, and inter-trial intervals were controlled by a computer running Inquisit version 1.32 software. This computer also managed the startle probe presentation. Another computer, running Spike2 version 3.17 software, controlled the physiological recording.

The eye blink startle response was measured electromyographically from the orbicularis oculi, using two miniature EL254S Ag/AgCl surface electrodes (Biopac

System, Inc) filled with Biopac electrode gel. This was done in the same way as in Study 2. The electrodes were centred approximately 0.8 cm below the pupil and outer canthus of the left eye. One electrode was placed under the pupil of the left eye and the second was placed laterally at a distance of approximately 1 cm, edge to edge. A ground electrode was attached to the participant's left forearm. The EMG signal was amplified by CED 1902 bio-amplifiers. The amplifier output was fed to the Power 1401 A/D converter (CED, Cambridge Electronic Design Limited, UK) under control of Spike2 (Cambridge Electronic Design Limited, UK) program interface installed in a PC/AT-compatible computer, which sampled the amplified EMG at 1000 Hz.

Skin conductance was recorded using two domed Ag/AgCl electrodes filled with a 0.05-M NaCl electrolyte. Again, this was done in the same way as in Study 2. The electrodes were placed on the distal phalanges of the index and second fingers of the left hand. A constant voltage of 0.5 V was applied across the electrodes and skin conductance was measured using a CED preamplifier and sampled at 20 Hz.

Horizontal eye movements between the spider and rabbit paired stimuli were measured using horizontal electrooculography (EOG). The EOG activity was registered using two miniature EL254S Ag/AgCl surface electrodes (Biopac System, Inc) filled with Biopac electrode gel. These were attached to the outer canthus of each eye and the signal was amplified using a CED 1902 bio-amplifier with a time constant of 0.16 Hz and 30Hz for the low pass filter. EOG data were collected at 510 Hz throughout the psychophysiological recording task.

Rating tasks. The stimuli used for the valence, arousal and perceived proximity rating tasks were the same as the individual stimuli used in the psychophysiological recording task.

All the computer tasks were presented in a dark, electrically isolated and soundproofed room. The pictorial stimuli for all experimental tasks were presented on a Viglen Pentium 120 PC with a 17-inch monitor in indexed 256 colour palette, using Inquisit version 1.32 software. The participants looked at the monitor down a black rectangular tunnel constructed in order to mask distance and depth cues. This was done in order to aid the perceived proximity manipulation. This also ensured that all participants are seated 83 cm from the monitor.

Procedure

Participants first completed a consent form. They were then seated, the electrodes were attached, and they were asked to put on the headphones. The tasks were presented in a fixed order for each participant, first the psychophysiological recording task, followed by the three ratings tasks. The psychophysiological recording task was first in order to ensure that habituation to the stimuli did not occur so as to maximise these measures (SCR in particular have been found to diminish rapidly with repeated picture presentation, Bradley M. et al., 1993). The order of the valence and arousal ratings task was counterbalanced between participants, with the perceived proximity rating task coming last.

The psychophysiological recording task commenced with five-minute rest period during which non-specific skin conductance responses, eye blink and eye movements were monitored. Participants were asked to relax with their eyes open during this period. After this participants were presented with six startle probes, presented one after than other with 12 s between each, so that the physiological signals could be checked. Then the participants were instructed that they would see a series of individual and paired pictures. They were told that each picture should be viewed for the entire time it is displayed (i.e. they should not look away from the screen) and that any acoustic stimuli should be ignored. Before the main block, the participants saw a set of 8 practice pictures and 2 buffer pictures with either no startle probe, a 300 ms startle probe or a 3000 ms startle probe. The main experimental block was then presented. This consisted of the 72 individual stimuli and the 72 paired stimuli, presented in a new mixed random order for each participant, for four seconds each. Inter-trial intervals had a minimum of six seconds with experimenter initiation of each subsequent trial, which varied between subjects. Trials were not initiated when the subject was moving or showed signs of increasing SCRs or slow eye-movements associated with sleep. For the trial presenting individual pictures, 24 were presented with a 300 ms startle probe, 24 were presented with a 3000 ms startle probe, and 24 were presented with no startle probe. There was an equal number of each stimulus type within each trial type (e.g. for the 24 trials showing individual pictures with a 300 ms startle probe, there were six proximal spiders, six distal spiders, six proximal rabbits and six distal rabbits). Which particular stimulus was shown with each probe condition varied between participants. For the 72 paired stimuli, 24 were presented with a 3000 ms startle probe in order to ensure that participants did not learn to associate single pictures with probes and double pictures with no probes.

Following this task were the three rating tasks. The valence rating task consisted of 72 trials in which each spider and rabbit picture was presented individually in a new random order for each participant. The picture was presented in the centre of the screen and underneath it appeared a nine point anchored rating scale. Each picture remained on screen until the participant responded, and then it was replaced by the next picture, after a 1000 ms inter-trial interval. The rating scale ranged from -4 (very unpleasant) to +4 (very pleasant) and participants were asked to press one of nine keys to indicate how pleasant or unpleasant they found each picture ("How pleasant or unpleasant do you find this picture?"). The arousal rating task and the perceived proximity rating task were identical except for the design of the rating scale. The arousal rating task had a nine-point rating scale which ranged from 0 (not at all arousing) to 8 (very arousing), and participants had to press one of nine keys to indicated how emotionally arousing they found each picture ("How emotionally arousing do you find this picture?"). The perceived proximity rating task was identical to those used in Studies 1 and 2. It had a 7-point rating scale which ranged from 1 (very close) to 7 (very far away), and participants were asked to press one of seven keys to indicated how close or far away they thought the animal in each picture was ("How close or far away do you think the animal in this picture is?").

Upon completion of these computer tasks, participants completed the Spider Phobia Questionnaire (SPQ; Watts and Sharrock, 1984) were debriefed.

Data Reduction and Analysis

Using the Spike2 3.17 programme, the startle eye blink data of each participant was analysed offline in the same way as in Study 2. The digitised EMG activity of orbicularis oculi were subjected to a bandpass filter with cut-off frequencies of 90 and 250 Hz (Bradley M. et al., 2001), the data were then rectified and integrated using a constant of 20 ms (8Hz). Measures of magnitude were derived from this integrated signal. The response peak for each trial was defined as the peak response between 21-150 ms after onset of the startle probe. The baseline magnitude for each trial was calculated as the mean measure of EMG activity of orbicularis oculi within the 150 ms before startle probe onset. The peak magnitude, in microvolts (μV), for each trial was calculated by subtracting the mean response from the peak response for that trial. All the trials were used in the analysis.

Using the Spike2 3.17 programme, the skin conductance responses (SCR) of each trial were analysed offline. Data were collected for one second previous to picture presentation and for seconds 1 - 4 of picture presentation (Codispoti et al., 2001). Data were analysed only for trials without a startle probe and with the startle at 3000 ms (48 trials). The magnitude of SCR for each trial was calculated by subtracting the mean SCR in the one second prior to picture presentation from the peak SCR during the picture presentation.

Using the Spike2 3.17 programme, the EOG data were analysed to detect left and right eye movements (EM) from the picture pairs with no startle probe (48 trials). First the data were exposed to a low pass filter at 20 Hz. A script programme was written and run by the Spike2 program in order to detect the eye movements during the attention task trials. This program used the following rules for identifying the left and right eye movements. An eye movement as measured by the EOG presents as a peak, with an initial slope to the peak as the initial movement and a final slope of natural decay away from the peak, the duration of the fixation. An eye movement to a picture was defined as having an initial slope with a rate of change in mV over time of greater than or equal to 0.3 mV/s occurring in a time window of 0.06 s and a final slope with a rate of change in mV over time of greater than or equal to 1 mV/s in a time window of 0.1 s. There was also a minimum and maximum threshold for the eye movement peak of 0.04 and 0.4 mV, under or over which did not correspond to eye movements to the pictorial stimuli. In this way, responses recorded by the EOG too small or large to be eye movements to the pictures, and those slow eye movements related to sleep and fatigue were not included in the analysis. The dependent measures were the direction and latency of the initial fixation and the amount of time spent looking at each picture in a pair over the 4000 ms of its presentation (dwell time).

EM-direction bias scores were obtained for each type of picture pair by calculating, for each participant, the number of trials in which the first eye movement was towards the critical stimulus, as a percentage of the number of trials of that particular type of pair with eye movements. There were no eye movement data collected from a mean of 1.75 (2.4%) trials in the LFG and 1.45 (2.0%) in the HFG. The number of missing trials did not differ significantly between the fear groups, $t(38) = 0.24$, *ns*. The EM-direction bias score for proximal spider pictures was the number of trials when the first EM was directed towards the proximal spider, divided by the total number of trials with EMs to proximal spider – proximal rabbit pairs. Therefore, a bias score greater than 50% indicated a preference to look first at proximal spiders rather than proximal rabbits, and a score of 50% reflects no bias. EM-direction bias scores were similarly calculated for distal spider – distal rabbit pairs.

Dwell time bias scores were calculated in a similar manner. These were calculated because the dwell time (ms) for each picture type was highly correlated across the whole sample and within each fear group (e.g. dwell time (ms) on spiders correlated negatively with that of rabbits $r(40) = -.98, p < .001$, for the proximal pictures, and $r(40) = -.97, p < .001$ for the distal pictures). Therefore, when the amount of time spent looking at the spider picture of a spider-rabbit pair was high, the amount of time looking at the rabbit picture of that pair was low. This means that picture type could not be entered into an analysis of variance (ANOVA) as an independent variable. For each trial, for each participant, the total amount of time spent looking at either picture was calculated (maximum was 4000 ms). Trials where this was less that 2000 ms were set to missing data. There was a mean of 1.75 (3.7%)

trials with missing data in the LFG and 1.6 (3.3%) in the HFG. The number of missing trials did not differ significantly between the fear groups, *t*(38) = 0.13, *ns*. Dwell time bias scores were obtained for each type of picture pair by calculating, for each participant, the amount of time spent looking at the spider stimulus, as a percentage of the total time spent looking at either picture for that particular type of picture pair. So, dwell time bias scores for proximal spider pictures was the amount of time spent looking at the proximal spider, divided by the total amount of time spent looking at the proximal spider – proximal rabbit pairs. Therefore, like the direction-bias score, a bias score greater than 50% indicated a preference to look longer at proximal spiders rather than proximal rabbits, and a score of 50% reflects no bias.

Results

Group Characteristics

The HFG had significantly higher scores on the SPQ, both at screening and at testing, (see Table 4.1 for means and *t*-test results).

Table 4.1 Fear Group Characteristics

	HFG		LFG			
	M	*SD*	*M*	*SD*	$t(38)$	*p*
SPQ (screening)	18.05	4.44	2.35	1.53	14.94	< .001
SPQ (experiment)	20.10	4.42	3.00	1.97	15.79	< .001
Age (years)	19.55	1.19	19.65	1.63	0.22	*ns*
Gender ratio, m/f	3/17		3/17			

Eye Movement Data

In general, participants were less likely to direct their gaze initially towards distal spiders than to proximal spiders. The high fear group showed a greater tendency than the low fear group to direct their gaze at spiders, relative to rabbits. Overall participants made faster initial EM to the rabbit pictures compared to the spider pictures.

EM-direction. EM-direction bias scores were entered into a mixed design analysis of variance (ANOVA) with perceived proximity (proximal vs. distal) as a within-subjects factor and fear group (high vs. low) as a between-subjects factor (see Table 4.2 for means). Kolmogorov-Smirnov tests showed that the distribution of the data did not differ significantly from normal. The results showed a main effect of perceived proximity, $F(1, 38) = 24.95, p < .001$. Participants, in general, were less likely to direct their gaze to distal spiders (44% of trials) than to proximal spiders (54% of trials), relative to rabbits. Overall, participants directed their gaze more frequently away from distal spiders towards distal rabbits; a one-sample *t*-test confirmed that this bias away from distal spiders and towards distal rabbits was significantly less than 50%, $t(39) = 4.13, p < .001$. There was only a trend for a difference from 50% for the more proximal spiders, $t(39) = 1.83, p = .075$. There was also a significant main effect of fear group, $F(1, 38) = 4.78, p < .05$. Overall, participants in the low fear group directed their gaze more frequently away from spiders and towards rabbits compared to the high fear group. A one-sample *t*-test showed that participants in the LFG directed their gaze more frequently away from the spiders, $t(39) = 2.46, p < .05$. There was no significant bias for spiders in the HFG, $t(39) = 0.94$, *ns*, see figure 4.1. The predicted fear group x perceived proximity interaction was not significant ($F < 1$).

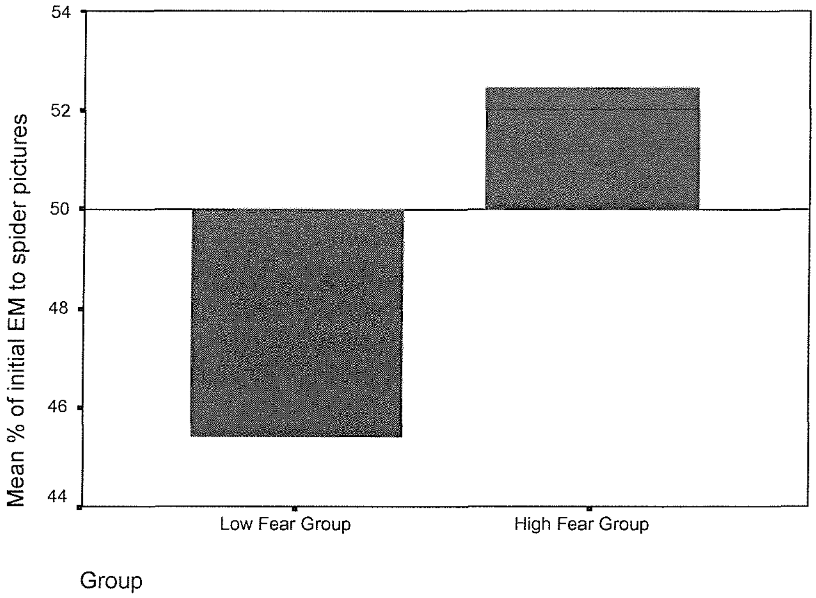

Figure 4.1 Mean direction of first EM (%)

Fixation latency. Latency data that were more than 2 *SD*s above the mean were excluded as outliers (6.6%)[12]. The data were log transformed to normalise the distribution. The logged data were entered into an ANOVA with one between-subjects factor of fear group (high vs. low) and two within-subjects factors of picture type (spider vs. rabbit) and perceived proximity (proximal vs. distal); see Table 4.2 for means. The results showed a significant main effect of picture type, $F(1, 38) = 24.86, p < .001$. Overall, participants made faster initial eye movements towards the rabbit pictures ($M = 369$ ms) compared to the spider pictures ($M = 393$ ms). The predicted fear group x picture type x perceived proximity interaction was not significant ($F < 1$).

Total dwell time. The dwell time bias scores were shown by a Kolmogorov-Smirnov test to not differ significantly from normal. The scores were entered into an ANOVA with perceived proximity (proximal vs. distal) as a within-subjects factor and fear group (high vs. low) as a between-subjects factor (see Table 4.2 for means). The results showed no significant main effects or interactions. The predicted fear group x perceived proximity interaction was not significant ($F < 1$).

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[12] The same pattern of results is observed when data more than 3 *SD*s above the mean are excluded (4.5%).

Table 4.2 Summary of Eye Movement Data for each Fear Group

Picture Type	HFG		LFG	
	M	*SD*	*M*	*SD*
	EM-direction bias scores (%)			
Proximal Spider	52.02	13.13	55.16	8.75
Distal Spider	42.59	6.57	44.94	6.37
	Latency of initial fixations (ms)			
Proximal Spider	401.28	179.21	400.35	202.88
Proximal Rabbit	380.08	126.65	393.95	281.23
Distal Spider	358.38	99.24	410.33	230.94
Distal Rabbit	358.50	103.20	341.97	125.81
	Dwell time (ms)			
Proximal Spider	1715.82	499.12	1838.61	403.88
Proximal Rabbit	1885.76	477.80	1778.29	414.45
Distal Spider	1649.27	516.87	1747.14	373.11
Distal Rabbit	1968.54	510.64	1893.54	395.70
	Dwell time bias scores (%)			
Proximal Spider	47.58	13.32	50.86	11.19
Distal Spider	45.54	14.06	48.01	10.25

Psychophysiological Data

The spiders stimuli elicited startle eye blink responses and increases in SCR magnitudes in participants in the HFG, compared to the LFG.

Startle eye blink response. One participant was excluded due to having over 25% missing data, so there were 19 participants in the HFG and 20 in the LFG. The mean eye blink magnitude data are displayed in Table 4.3. The data were entered into an ANOVA with one between-subjects factor of fear group (high vs. low) and three within-subjects factors of picture type (spider vs. rabbit), perceived proximity (proximal vs. distal), and lead time of startle probe (300 ms vs. 3000 ms). The results showed a main effect of perceived proximity, $F(1, 37) = 6.25, p < .05$, picture type, $F(1, 37) = 4.33, p < .05$, and time, $F(1, 37) = 7.56, p < .01$. There were also significant perceived proximity x group interaction, $F(1, 37) = 4.33, p < .05$, and picture type x group interaction, $F(1, 37) = 4.21, p < .05$. The predicted fear group x picture type x perceived proximity interaction was not significant ($F < 1$).

To clarify the perceived proximity x group interaction, post hoc tests showed that the HFG demonstrated a larger magnitude of startle to proximal pictures ($M = 9.7$ µv) compared to distal pictures ($M = 7.8$ µv), $t(18) = 2.93, p < .01$. There was no difference in the LFG between the magnitude of startle to proximal pictures ($M = 7.3$ µv) and to distal pictures ($M = 7.2$ µv), $t(19) = 0.02$, *ns*. To clarify the picture type x group interaction, post hoc tests showed that the HFG had larger magnitude of startle to spider pictures ($M = 1.02$ µv) compared to the to rabbit pictures ($M = 0.74$ µv), $t(18) = 2.21, p < .0125$. There was no difference in the magnitude of startle between the spider ($M = 0.72$ µv) and rabbit ($M = 0.72$ µv) pictures in the LFG, $t(19) = 0.04$, *ns*, see Figure 4.2[13].

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[13] These post hoc differences remained so when using a Bonferroni adjustment ($p < .0125$).

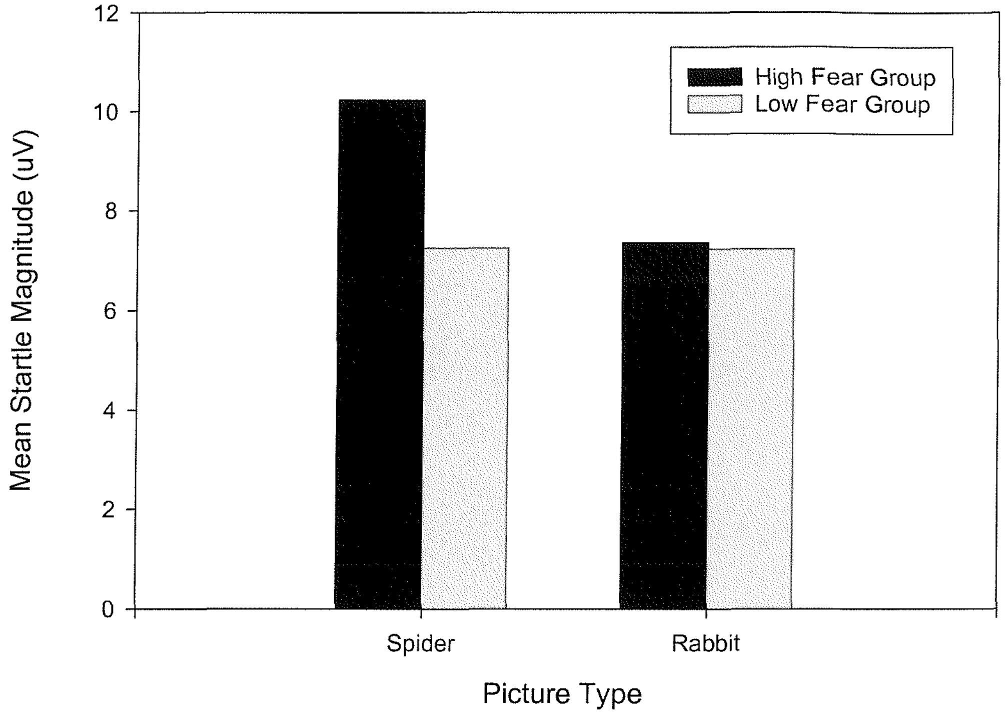

Figure 4.2 Mean eye blink startle magnitudes (μv)

Skin conductance responses (SCR). The mean SCR data are displayed below in Table 4.3. The data were log transformed to normalise the distribution (see Bradley M. et al., 2001). The logged data were entered into an ANOVA with picture type (spider vs. rabbit) and perceived proximity (proximal vs. distal) as a within-subjects factors and fear group (high vs. low) as a between-subjects factor. The results showed a main effect of fear group, $F(1, 38) = 4.07, p = .05$, and picture type, $F(1, 38) = 4.98, p < .05$. These were subsumed within a significant fear group x picture type interaction, $F(1, 38) = 4.98, p = 0.05$. Post hoc tests showed that the HFG had higher SCRs for the spiders than the LFG, $t(38) = 2.19, p < .0125$. However, there was no difference between the groups in their SCRs to the rabbits, $t(38) = 1.05$, *ns*. The HFG's SCRs to the spider pictures were also greater than their SCRs to the rabbits, $t(19) = 2.679, p < .0125$. However, the LFG's SCRs elicited by the spiders did not differ from those elicited by the rabbits, *t*(19) = .22, *ns*; see Figure 4.3[14]. The predicted fear group x picture type x perceived proximity interaction was not significant (*F* < 1).

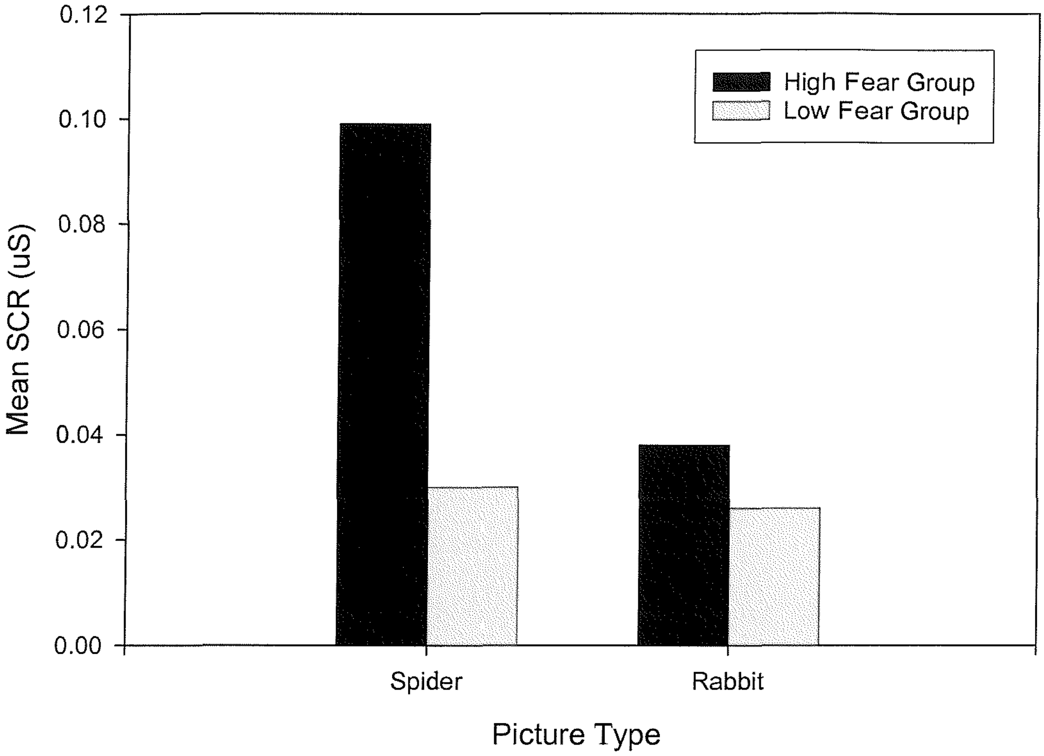

Figure 4.3 Mean SCR (μS)

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[14] Again, using a Bonferroni correction to adjust the significance to the .0125 level these results remain the same.

Table 4.3 Mean Physiological Responses

	HFG		LFG	
Picture Type	*M*	*SD*	*M*	*SD*
	Startle eye blink magnitudes (µv)[15]			
Proximal Spider 300 ms startle	10.9	13.5	6.7	11.7
Proximal Spider 3000 ms startle	12.1	12.8	8.4	11.9
Proximal Rabbit 300 ms startle	7.8	7.5	6.3	11.0
Proximal Rabbit 3000 ms startle	8.2	8.4	7.6	13.3
Distal Spider 300 ms startle	9.2	12.3	5.9	10.1
Distal Spider 3000 ms startle	8.8	9.3	8.0	14.6
Distal Rabbit 300 ms startle	6.0	5.1	6.3	12.6
Distal Rabbit 3000 ms startle	7.5	8.3	8.7	15.8
	SCR magnitudes (uS)			
Proximal Spider	0.12	0.17	0.04	0.16
Proximal Rabbit	0.04	0.08	0.02	0.09
Distal Spider	0.08	0.12	0.02	0.05
Distal Rabbit	0.04	0.07	0.03	0.06

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[15] The pattern of results is the same when using a log transformation to normalise the distribution.

Perceived Proximity Rating Task

Overall, participants rated the proximal pictures as being perceived to be closer than the distal pictures.

The perceived proximity ratings were shown by Kolmogorov-Smirnov tests to be normally distributed. The ratings were entered into a repeated measures ANOVA, with two within-subjects variables of perceived proximity (proximally versus distally perceived) and picture type (spider versus rabbit), and one between-subjects variable of group (high versus low fear group); see Table 4.4 for means. The results showed main effects of fear group, $F(1, 38) = 11.37, p < .01$, picture type, $F(1, 38) = 29.47, p < .001$, and perceived proximity, $F(1, 42) = 364.01, p < .001$. These were subsumed within a significant fear group x picture type x perceived proximity interaction, $F(1, 38) = 5.03, p < .05$.

Two further ANOVAs were performed to look at this interaction. First, an ANOVA was carried out for the LFG, with perceived proximity (proximal vs. distal) and picture type (spider vs. rabbit) as independent variables, only showed significant main effect of perceived proximity, $F(1, 19) = 192.38, p < .001$, as they rated the proximal stimuli to be closer than the distal stimuli. . A similar ANOVA carried out for the HFG showed significant main effects of picture type, $F(1, 19) = 46.57, p < .001$, and perceived proximity, $F(1, 19) = 171.75, p < .001$, and a significant picture type x perceived proximity interaction, F(1, 19) = 4.29, p = .05.

Post-hoc tests indicated that, in general, participants found the proximal stimuli (both spiders ($t(39) = 17.58, p < .001$) and rabbits ($t(39) = 18.67, p < .001$)) to be closer than the distal stimuli (both spiders and rabbits). Participants in the HFG also rated the proximal spiders as being closer than the proximal rabbits, ($t(19) = 5.58$, $p < .001$) and the distal spiders as being closer than the distal rabbits, ($t(19) = 6.33, p$

$< .001)$[16]. The interaction indicates that this effect is somewhat larger for the distal stimuli.

Table 4.4 Perceived Proximity Rating Means

Picture Type	HFG		LFG	
	M	*SD*	*M*	*SD*
Proximal Spider	1.19	0.22	1.78	0.37
Proximal Rabbit	1.99	0.71	2.12	1.05
Distal Spider	4.06	1.15	5.03	1.07
Distal Rabbit	5.18	0.88	5.49	0.66

Valence Rating Task

In general, participants rated the proximal spiders and distal spiders as being more negatively valenced than the proximal and distal rabbits, although this effect was less for the distal pictures. The HFG found the spider pictures to be more negatively valenced, and the rabbit pictures more positively valenced, than the LFG,

Kolmogorov-Smirnov tests showed the data distributions were not significantly different from the normal distribution. The valence rating data were entered into a mixed design ANOVA with one between-subjects factor of fear group (high vs. low) and two within-subjects factors of picture type (spider vs. rabbit) and perceived proximity (proximal vs. distal); see Table 4.5 for means. The results showed main effects of fear group, $F(1, 38) = 29.00, p < .001$, picture type, $F(1, 38) = 255.18, p < .001$, and perceived proximity, $F(1, 38) = 13.99, p < .01$. There was also a group x picture type interaction, $F(1, 38) = 93.64, p < .001$, and a picture type x

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[16] These results remain the same when using a Bonferroni correction ($p < .0083$).

perceived proximity interaction, *F*(1, 38) = 58.23, $p < .001$. These were subsumed within a significant fear group x picture type x perceived proximity interaction, *F*(1, 38) = 4.97, $p < .05$.

In order to explore this interaction, two further ANOVAs were performed. An ANOVA carried out for the HFG, with perceived proximity (proximal vs. distal) and picture type (spider vs. rabbit) as independent variables, showed significant main effects of picture type, *F*(1, 19) = 493.50, $p < .001$, and perceived proximity, *F*(1, 19) = 10.48, $p < .001$, and a significant picture type x perceived proximity interaction, F(1, 19) = 58.45, p < .001. Post hoc tests indicated that the HFG, in general, found the proximal spiders more negatively valenced than the proximal rabbits (*t*(19) = 25.36, $p < .001$) and the distal spiders more negatively valenced than the distal rabbits (*t*(19) = 17.39, $p < .001$), although the picture type x perceived proximity interaction suggests that this effect is somewhat smaller for the distal stimuli. The HFG found both the proximal and distal spider pictures more negatively valenced (proximal: *t*(38) = 11.69, $p < .001$; distal: *t*(38) = 11.09, $p < .001$) and both the proximal and distal rabbit pictures more positively valenced (proximal: *t*(38) = 3.13, $p < .01$; distal: *t*(38) = 3.12, $p < .01$) than the LFG[17].

A similar ANOVA was carried out for the LFG also showed significant main effects of picture type, *F*(1, 19) = 14.87, $p < .01$, and perceived proximity, *F*(1, 19) = 4.88, $p < .05$, and a significant picture type x perceived proximity interaction, F(1, 19) = 12.49, $p < .01$. Post-hoc tests indicated participants in the LFG also found the proximal spiders more negatively valenced than the proximal rabbits (*t*(19) = 4.03, $p < .01$) and the distal spiders more negatively valenced than the distal rabbits (*t*(19) = 3.39, $p < .01$), although again the picture type x perceived proximity interactions

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[17] Again, these results remain the same using a Bonferroni corrected significance at the .0125 level.

suggest this effect is somewhat smaller for the distal stimuli. See Figure 4.4 below for an illustration of these results.

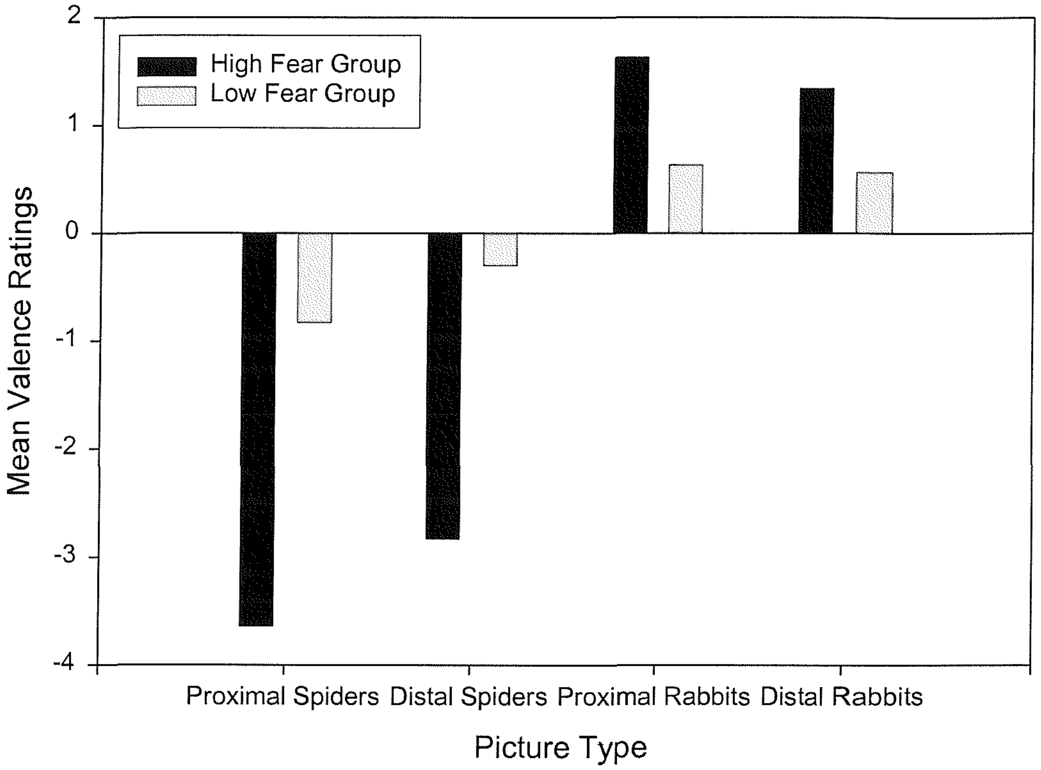

Figure 4.4 Mean Valence Ratings

Table 4.5 Valence Rating Means

Picture Type	HFG		LFG	
	M	*SD*	*M*	*SD*
Proximal Spider	-3.64	0.47	-0.83	0.97
Proximal Rabbit	1.63	0.67	0.63	1.26
Distal Spider	-2.83	0.81	-0.30	0.62
Distal Rabbit	1.34	0.59	0.56	0.95

Arousal Rating Task

In general, participants found the proximal stimuli more arousing than the distal stimuli. The HFG found both the proximal and the distal spiders more arousing than the LFG, and also found the proximal and distal spider pictures more arousing than the proximal and distal rabbit pictures.

The distributions of the arousal rating data were shown to not differ from normal by Kolmogorov-Smirnov tests. The data were entered into a mixed design ANOVA with one between-subjects factor of fear group (high vs. low) and two within-subjects factors of picture type (spider vs. rabbit) and perceived proximity (proximal vs. distal); see Table 4.6 for means. The results showed main effects of fear group, $F(1, 38) = 29.42, p < .001$, picture type, $F(1, 38) = 54.71, p < .001$, and perceived proximity, $F(1, 38) = 58.48, p < .001$. There was also a group x picture type interaction, $F(1, 38) = 44.94, p < .001$, and a picture type x perceived proximity interaction, $F(1, 38) = 45.43, p < .001$. There was also a significant fear group x picture type x perceived proximity interaction, $F(1, 38) = 6.64, p < .05$.

In order to explore this interaction, two further ANOVAs were performed. An ANOVA carried out for the HFG, with perceived proximity (proximal vs. distal) and picture type (spider vs. rabbit) as independent variables. This showed a significant main effects of picture type, $F(1, 19) = 91.58, p < .001$, and perceived proximity, $F(1, 19) = 46.76.81, p < .001$, and a significant picture type x perceived proximity interaction, $F(1, 19) = 30.81$, $p < .001$. Post hoc tests showed that the HFG, in general, found the proximal stimuli (both spiders, $t(19) = 7.41, p < .001$, and rabbits, $t(19) = 3.10, p < .005$) to be more arousing than the distal stimuli, although the interaction indicates that this effect was somewhat larger for the spider stimuli. The HFG found both the proximal ($t(38) = 8.02, p < .001$) and distal ($t(38) = 7.05, p < .001$) spiders more arousing than the LFG. Only the HFG also found the proximal spiders more arousing than the proximal rabbits ($t(19) = 11.32, p < .001$), and the distal spiders more arousing than the distal rabbits ($t(19) = 7.36, p < .001$)[18].

A similar ANOVA carried out for the LFG showed a significant main effect of perceived proximity, $F(1, 19) = 18.52, p < .001$, and a significant picture type x perceived proximity interaction, F(1, 19) = 14.67, $p < .01$. Post hoc tests indicated that the LFG also found the proximal stimuli (both spiders, $t(19) = 4.64, p < .001$, and rabbits, $t(39) = 3.30, p < .001$) to be more arousing than the distal stimuli, although again the interaction indicates that this effect was somewhat larger for the spider stimuli. See Figure 4.5 for an illustration of these results.

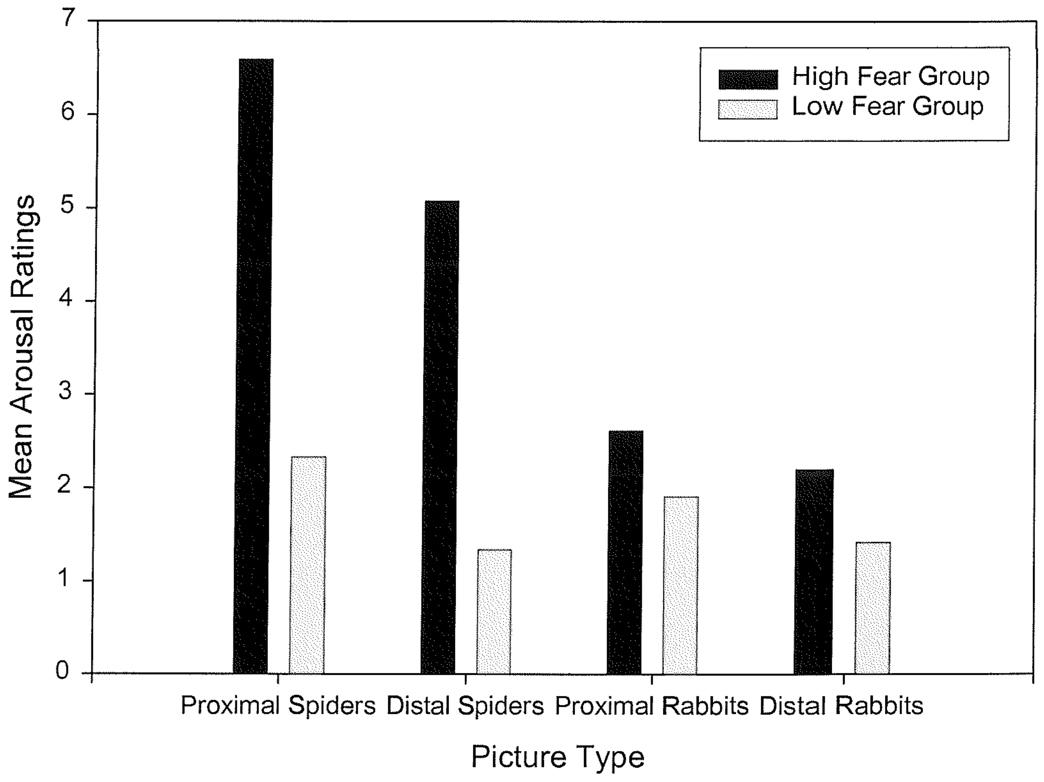

Figure 4.5 Mean Arousal Ratings

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[18] These post hoc results remain the same under a Bonferroni corrected significance level ($p < .0083$).

Table 4.6 Arousal Rating Means

Picture Type	HFG		LFG	
	M	*SD*	*M*	*SD*
Proximal Spider	6.59	1.55	2.33	1.80
Proximal Rabbit	2.61	1.72	1.91	1.62
Distal Spider	5.08	1.96	1.34	1.33
Distal Rabbit	2.20	1.50	1.42	1.46

Correlations

Correlations were calculated between the SPQ[19] and the eye movement, psychophysiological, and rating task measures for the whole sample. Increased SPQ scores were associated with greater SCR elicited by both the more proximal ($r(40) = .32, p < .05$) and the more distal ($r(40) = .36, p < .05$) spiders. Increased SPQ scores were also associated with lower valence ratings for the proximal ($r(40) = -.87, p < .001$) and the distal ($r(40) = -.69, p < .001$) spiders, higher arousal ratings of the proximal spiders ($r(40) = .75, p < .001$), and closer perceived proximity ratings for the proximal ($r(40) = -.64, p < .001$) and the distal spiders ($r(40) = -.46, p < .01$).

Other significant correlations between measures are reported. A greater percentage of first EM towards the proximal spiders is associated with lower startle magnitudes elicited by the proximal spiders ($r(39) = -.48, p < .01$) and lower valence ratings of the proximal spiders ($r(40) = -.35, p < .05$). Similarly, a greater percentage of first EM towards the distal spiders is associated with lower startle magnitudes elicited by the distal spiders ($r(39) = -.34, p < .05$). Finally, greater SCR elicited by

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[19] A Kolmogorov-Smirnov test showed the distribution of SPQ scores not to differ significantly from the normal distribution.

the proximal spiders are associated with greater ratings of arousal of the proximal spiders ($r(40) = .34, p < .05$).

Discussion

The aim of this study was to assess how attentional allocation and physiological responses are affected by the perceived proximity of threatening stimuli. This was done by using a hybrid task in which eye movements, startle eye blinks, and SCRs were measured. It was hoped that getting concurrent measures of physiological responses and attentional allocation would allow for a clear picture of how a threat's perceived proximity influences the behaviour it elicits.

The results show that the fear groups differ in the direction of initial eye movement, startle response and SCRs to the spider stimuli. The high fear group had larger startle eye blinks and SCRs when looking at pictures of spiders compared to the low fear group. The high fear group also demonstrated a greater tendency to direct their first eye movement towards the spider stimuli, relative to the rabbit stimuli, compared to the low fear group. These findings are in line with various theoretical models discussed (e.g. Öhman, 1994) which predict individuals will have different responses to stimuli they find aversive compared to individuals who do not find the stimuli aversive. However, none of the measures showed that these group differences were influenced by the perceived proximity manipulation.

The first issue to consider is whether the manipulation of perceived proximity was effective. The results of the perceived proximity rating task suggest that participants found the proximal pictures to be closer than the distal ones. However, the fact that none of the various measured showed seemed to be influenced by perceived proximity suggests that this manipulation is not strong enough. The previous study only found a potentiated startle response in the HFG for the proximal spiders, however this study demonstrated this effect it for all spiders. This perhaps indicated that the difference between the proximal and distal spiders is not great enough to ensure a reliable difference in response in the startle measure. This idea could be examined by increasing the difference in perceived proximity between the proximal and distal stimuli.

A second question is whether the proximally perceived spider stimuli used in this study were of sufficient threat value. These are the same stimuli as were used in Study 2, in which was observed that the proximal spider stimuli elicited a potentiated startle response in the high fear group. This would indicate that these stimuli are sufficiently threatening and do elicit different responses from the distal spiders in spider-fearful participants. Indeed, although the physiological task which assessed both attentional allocation and physiological responses did not indicate these differences, the results of the rating tasks suggest that they did exist. The valence and arousal rating tasks indicated that the perceived proximity of the spider stimuli did influence how negative and how arousing they were perceived to be. Participants in the HFG found both the proximal and the distal spiders more negative and more arousing than participants in the LFG. Participants in general, however, rated both the proximal and distal spiders to be more negatively valenced than their rabbit counterparts.

The following study presents another attempt to assess the differing predictions behavioural and cognitive models have concerning the effect of a threat's perceived proximity on the behaviours of individuals. In order to narrow down the reasons for the lack of clarity in the present results, the next study will involve a broadening of the present study, with a greater distinction between the sizes of the proximally and distally perceived stimuli. This will be done in an effort to strengthen the manipulation of perceived proximity.

Chapter Five: Study 4: Physiological Responses and Attentional Allocation to Proximally and Distally Perceived Stimuli in Spider Fear – A Greater Distinction Between Proximal and Distal Pictures

Abstract

The aim of this study was to examine the effect of perceived proximity on the physiological responses and attentional allocation to spider cues in spider fear. The study used a hybrid task, similar to that in Study 3, in which individual and paired pictures of distally and proximally perceived rabbits and spiders were displayed. The stimuli were projected onto a screen in order to increase the ratio in size between the proximal and distal pictures. The task enabled the monitoring of startle eye blink responses, skin conductance response (SCR), and eye movements (EM) to occur in the same task. The results of the eye movement measures showed no significant differences between the fear groups. The results of the physiological measures showed that the high fear group had greater startle eye blinks when viewing the proximal spiders pictures. There were no significant results for the SCR measure. The finding from the startle data, which replicates an earlier one presented in Study 2, provides some support for the prediction made by several of the models based on animal research (e.g. Lang et al., 1997) that proximal threat is more likely to elicit an active defence response.

Introduction

This study was an extension of Study 3, reported in the previous chapter. Therefore, it involved the same hybrid task design in order to measure attentional and physiological responses to stimuli presented at different perceived proximities. The main difference concerned how the stimuli were displayed. The ratio between the sizes of the proximal and distal stimuli was increased and the stimuli were projected onto a screen rather than a computer monitor. This was done in order to investigate the effect of perceived proximity of threat cues in the various attentional and physiological responses in high and low spider-fearful groups.

To recap briefly, the idea that a threat's perceived proximity influences the type of defence behaviours it elicits in an individual is central in many theoretical models (e.g. Blanchard & Blanchard, 1988; Fanselow, 1994; Lang et al., 1997; McNaughton & Gray, 2000). A distal threat will elicit sensory processing behaviours in which attention is oriented towards the threat. A proximal threat, on the other hand, will lead to a loss of this vigilance in favour of active defence responses. Lang et al. (1997) predict that the orienting response involves an inhibition of the startle reflex and only a moderate SCR. However, the active defence behaviours involve a potentiated startle response and SCR. Therefore, the perceived proximity of a threat is important in determining what type of defence behaviour is displayed.

However, as noted earlier in this thesis, no published studies have so far examined the effect of manipulating the perceived proximity of the threatening stimulus on physiological and attentional responses. Previous studies in this thesis have had mixed success in using the manipulation of the perceived proximity of a threat stimulus in order to assess such responses. Study 2 showed that the proximity of threat affected startle eye blink magnitudes – participants who were fearful of spiders only demonstrated a potentiated startle response to auditory probes whilst looking at the more proximal spider pictures. However, this finding was not replicated in Study 3, which showed enhanced startle responses in the HFG irrespective of the perceived proximity condition (i.e. proximal vs. distal). This study further investigated predictions from models (e.g. Lang et al., 1997) by increasing the strength of the perceived proximity manipulation and by using a projector to present the stimuli. Furthermore, the presentation of the stimuli was also modified so that the proximal stimuli occupied all of the stimulus area whereas the distal stimuli only occupied about 2% (rather than about 11%) of the stimulus area. As with the two previous studies, the stimuli were made up of spider and rabbit colour pictures and were shown to spider-fearful and non-fearful participants. The dependent measures taken were the same as the Study 3, namely eye movements in order to assess attentional allocation, and startle eye blink magnitude and SCR in order to assess physiological responses of orienting and defensive activation. Two subjective rating tasks were also used. One to assess the success of the perceived proximity manipulation, and the other to assess how much fear/anxiety the stimuli elicit.

In line with the theoretical models based on animal research (e.g. Fanselow, 1994; Lang et al., 1997), it is hypothesised that the distally perceived spider stimuli will not elicit any physiological responses associated with defensive activation, even in the high fear group. Rather, these stimuli will elicit an attentional assessment and physiological orienting response in the spider-fearful participants. The proximally perceived spider stimuli are predicted to elicit greater defensive activation in the high fear group, with a loss of enhanced orienting.

Method

Participants

Forty-one participants were recruited from undergraduates reading psychology at the University of Southampton. Potential participants filled out the Spider Phobia Questionnaire (SPQ; Watts & Sharrock, 1984) and selection criteria for participants were that they scored either 4 or less or 12 or more on the SPQ. Twenty participants were recruited into the low fear group (LFG) and 21 into the high fear group (HFG).

Materials and Apparatus

Psychophysiological recording task. Like Study 3, there were two types of stimuli (spiders and rabbits) and two trial types used during the psychophysiological recording task. The first trial type consisted of 72 individually presented colour pictures. These were eighteen colour spider pictures and 18 colour rabbit pictures. These pictures came in two perceived proximity conditions; each was presented once as a proximal stimulus and once as a distal stimulus (see *Appendix Two*). The pictures measured 22 cm by 22 cm; in the proximal stimuli the rabbit/spider took up about 100% of the picture area and in the distal stimuli the rabbit/spider took up about 2% of the picture area. As the participants were seated 200 cm from the projector screen, the proximally perceived pictures appeared to be approximately 50 times larger than the distal ones. The proximal stimuli subtended 6.3° of visual angle and the distal stimuli subtended 0.9° of visual angle. Therefore, the ratio between proximal and distal is far larger in this study than in previous ones (where the proximal pictures were only approximately 9 times larger than the distal ones). The second trial type involved 36 colour pairs of spider-rabbit pictures. These pairs were made up of the same pictures as the individual stimuli, matched for perceived proximity and colour. The paired stimuli were presented one on either side of centre with a distance of 7.2 cm between the inside edges. Participants were seated 2 m from the projector screen. Each pair was presented twice, counterbalanced for the side of the spider picture. Therefore, there were 72 trials of paired stimuli presented. In addition to these stimuli, ten practice/buffer pictures were used. These were five individually presented pictures of cats or hamsters, two of which were proximal and three of which were distal. There were also five cat-hamster paired stimuli presented, again two pairs of which were of proximal stimuli and three of which were distal stimuli.

An acoustic startle stimulus was used during the psychophysiological recording task. This was a 50 ms burst of 95-dB(A) white noise with a nearly instantaneous rise/fall time. It was generated by a white noise generator, gated by script program running by Spike2 (r) program (Cambridge Electronic Design) and presented binaurally through Sony DR-3A headphones.

During the psychophysiological recording task all stimuli presentation and physiological recording was controlled by two PC/AT-class microcomputer running special software packages. The visual stimuli sequence, their durations, and inter-trial intervals were controlled by a computer running Inquisit version 1.32 software. This computer also managed the startle probe presentation. Another computer, running Spike2 version 3.17 software, controlled the physiological recording.

The eye blink startle response was measured electromyographically from the orbicularis oculi, using two miniature EL254S Ag/AgCl surface electrodes (Biopac System, Inc) filled with Biopac electrode gel. This was done in the same way as in Studies 3 and 4. The electrodes were centred approximately 0.8 cm below the pupil and outer canthus of the left eye. One electrode was placed under the pupil of the left eye and the second was placed laterally at a distance of approximately 1 cm, edge to edge. A ground electrode was attached to the participant's left forearm. The EMG signals were amplified by CED 1902 bio-amplifiers. Amplifier output was fed to the Power 1401 A/D converter under control of Spike2 program interface installed in a PC/AT-compatible computer, which sampled the amplified EMG at 1000 Hz.

Skin conductance responses were also measured in the same way as Studies 2 and 3. They were recorded using two Ag/AgCl electrodes filled with a 0.05-M NaCl electrolyte. These electrodes were placed on the distal phalanges of the index and second fingers of the left hand. A constant voltage of 0.5 V was applied across the electrodes and skin conductance was measured using a CED preamplifier and sampled at 20 Hz.

Horizontal eye movements between the spider and rabbit paired stimuli were measured using horizontal electrooculography (EOG). The EOG activity was registered using two miniature EL254S Ag/AgCl surface electrodes (Biopac System, Inc) filled with Biopac electrode gel. These were attached to the outer canthus of each eye and the signal was amplified using a CED 1902 bio-amplifier (1:3000 uV) with a time constant of 0.16 Hz and 30 Hz for the low pass filter. Data were collected at 510 Hz throughout the psychophysiological recording task.

The rating tasks. The stimuli used for the perceived proximity and fear/anxiety rating tasks were the same as the individual stimuli used in the psychophysiological recording task.

All of the computer tasks were presented in a dark, electrically isolated and soundproof room. The pictorial stimuli for all experimental tasks were presented on a

Viglen Pentium 120 PC and projected onto a screen using a Sony projector, using Inquisit version 1.32 software. A chin rest was used in order to keep their heads still. This was done to ensure that participants moved their eyes to look at the paired stimuli rather than their heads.

Procedure

Participants first completed a consent form. They were then seated, the electrodes were attached, and they were asked to put on the headphones. The tasks were presented in a fixed order for each participant, first the psychophysiological recording task, followed by the two ratings tasks. The psychophysiological recording task was first to reduce the effect of habituation to the stimuli (SCR in particular have been found to diminish rapidly with repeated picture presentation, Bradley M. et al., 1993). The participants then took part in the fear/anxiety rating task and the perceived proximity rating task.

The psychophysiological recording task commenced with five-minute rest period during which non-specific skin conductance responses, eye blink and eye movements were monitored. Participants were asked to relax with their eyes open during this period. After this, participants were presented with six startle probes, presented one after the other with a 12 s gap between probes, so that physiological signals could be checked. Then the participants were instructed that they would see a series of individual and paired pictures and that any acoustic stimuli should be ignored. They were asked to look at the screen throughout the experiment. The participants then saw a set of eight practice pictures and two buffer pictures with either no startle probe, a 300 ms startle probe or a 3000 ms startle probe. The main experimental block was then presented. This consisted of the 72 trials of individual stimuli and the 72 trials of paired stimuli, presented in a new random for each participant. Each trial had the stimuli presented for 4 s. Inter-trial intervals had a minimum of 6 s with experimenter initiation of each subsequent trial, which varied between subjects. Trials were not initiated when the subject was moving or showed signs of increasing SCRs or eye movements associated with sleep. For the trials presenting individual pictures, 24 were presented with a 300 ms startle probe, 24 were presented with a 3000 ms startle probe, and 24 were presented with no startle probe. There was an equal number of each stimulus type within each trial type (e.g. for the 24 trials showing individual pictures with a 300 ms startle probe, there were six proximal spiders, six distal spiders, six proximal rabbits and six distal rabbits). Which particular stimulus was shown with each probe condition varied between participants. For the 72 paired stimuli, 24 were presented with a 3000 ms startle probes in order to ensure that participants did not learn to associate single pictures with probes and double pictures with no probes.

Following this task, participants completed the fear/anxiety rating task and the perceived proximity rating task. The fear/anxiety rating task consisted of 72 trials in which each spider and rabbit picture was presented individually in a new random order for each participant. The picture was presented in the centre of the screen and underneath it appeared a 7-point anchored rating scale. Each picture remained on screen until the participant responded, and then it was replaced by the next picture, after a 1000 ms inter-trial interval. The rating scale ranged from 1 (not at all fearful/anxious) to 7 (very fearful/anxious) and participants were asked to press one of seven keys to indicated how fearful/anxious each picture made them feel ("How fearful/anxious does this picture make you feel?"). The perceived proximity rating task was identical except the rating scale ranged from 1 (very close) to 7 (very far away), and participants were asked to press one of seven keys to indicated how close or far away they thought the animal in each picture was ("How close or far away do you think the animal in this picture is?").

Upon completion of these computer tasks, participants the Spider Phobia Questionnaire (SPQ; Watts and Sharrock, 1984) and were debriefed.

Data Reduction and Analysis

Using the Spike2 3.17 programme, the startle eye blink data of each participant was analysed offline in the same way as in Studies 2 and 3. The digitised EMG activity of orbicularis oculi was subjected to a bandpass filter with cut-off frequencies of 90 and 250 Hz (Bradley M. et al., 2001), the data were then rectified and integrated using a constant of 20 ms (8 Hz). Measures of magnitude were derived from this integrated signal. The response peak for each trial was defined as the peak response between 21-150 ms after onset of the startle probe. The baseline magnitude for each trial was calculated as the mean measure of EMG activity of orbicularis oculi within the 150 ms before startle probe onset. The peak magnitude, in microvolts (μV), for each trial was calculated by subtracting the mean response from the peak response for that trial. All the trials were used in the analysis.

Using the Spike2 3.17 programme, the skin conductance responses (SCR) of each trial were analysed offline, and in the same way as way done in Studies 2 and 3. Data were collected for 1 s previous to picture presentation and for seconds 1-4 of picture presentation (Codispoti et al, 2001). Data were analysed only for trials without a startle probe and with the startle at 3000 ms (48 trials). The magnitude of SCR for each trial was calculated by subtracting the mean SCR in the 1 s prior to picture presentation from the peak SCR recorded during the picture presentation.

Using the Spike2 3.17 programme, the EOG data were analysed to detect left and right eye movements (EM) from the picture pairs with no startle probe (48 trials). This was done in the same way as in Study 3. First the data were exposed to a low pass filter at 20 Hz. A script programme was written and run by the Spike2 program in order to detect the eye movements during the attention task trials. This program used the following rules for identifying the left and right eye movements. An eye movement, as measured by EOG, is presented as a peak. The initial slope to the peak is the initial movement and the final slope, the natural decay away from the peak, the duration of the fixation. An eye movement to a picture was defined as having an initial slope with a rate of change in mV over time of greater than or equal to 0.3 mV/s occurring in a time window of 0.06 s and a final slope with a rate of change in mV over time of greater than or equal to 1 mV/s in a time window of 0.1 s. There was also a minimum and maximum threshold for the eye movement peak of 0.04 and 0.4 mV, under or over which did not correspond to eye movements to the pictorial stimuli. In this way, responses recorded by the EOG too small or large to be eye movements to the pictures, and those slow eye movements related to sleep and fatigue were not included in the analysis. The dependent measures were the direction and latency of the initial fixation and the amount of time spent looking at each picture in a pair over the 4000 ms of its presentation (dwell time).

As was done in Study 3, EM-direction bias scores were obtained for each type of picture pair. This was done by calculating, for each participant, the number of trials in which the first eye movement was towards the critical stimulus, as a percentage of the number of trials of that particular type of pair with detectable eye movements.

There was no eye movement data collected from a mean of 1.33 (1.9%) of trials in the LFG and 1.71 (2.4%) of trials in the HFG. The number of missing trials did not differ significantly between the fear groups, *t*(38) = 0.13, *ns*. The EM-direction bias score for proximal spider pictures was the number of trials when the first EM was directed towards the proximal spider, divided by the total number of trials with EMs to proximal spider – proximal rabbit pairs. Therefore, a bias score greater than 50% indicated a preference to look first at proximal spiders rather than proximal rabbits, and a score of 50% reflects no bias. EM-direction bias scores were similarly calculated for distal spider – distal rabbit pairs.

Dwell time bias scores were calculated in a similar manner, and in the same way as was done in Study 3. These were calculated because the dwell time (ms) for each picture type was highly correlated across the whole sample and within each fear group (e.g. dwell time (ms) on spiders correlated negatively with that of rabbits, *r*(38) = -.96, *p* < .001, for proximal pictures, and *r*(38) = -.99, *p* < .001, for distal pictures). Therefore, when the amount of time spent looking at the spider picture of a spider-rabbit pair was high, the amount of time spent looking at the rabbit picture of that pair was low. This means that picture type cannot be entered into an analysis of variance (ANOVA) as an independent variable. For each trial, for each participant the total amount of time spent looking at either picture was calculated (maximum was 4000 ms). Trials where this was less that 2000 ms were set to missing data. There was a mean of 1.65 (3.4%) trials with missing data in the LFG and 1.10 (2.3%) in the HFG. The number of missing trials did not differ significantly between the fear groups, *t*(36) = 0.62, *ns*. Dwell time bias scores were obtained for each type of picture pair by calculating, for each participants, the amount of time spent looking at the spider stimulus, as a percentage of the total time spent looking at either picture for that particular type of picture pair. Therefore, like the direction-bias score, a bias score greater than 50% indicated a preference to look longer at proximal spiders rather than proximal rabbits, and a score of 50% reflects no bias.

Results

Group Characteristics

The HFG had significantly higher scores on the SPQ (both at screening and testing) compared with the LFG (see Table 5.1 for means and *t*-test results).

Table 5.1 Fear Group Characteristics

	HFG		LFG			
	M	*SD*	*M*	*SD*	*t*(39)	*p*
SPQ (screening)	20.00	2.95	2.55	1.47	23.79	< .001
SPQ (experiment)	20.38	3.72	2.75	1.86	19.04	< .001
Age (years)	26.90	10.81	25.55	6.92	0.48	*ns*
Gender, m/f	2/19		0/20			

Eye Movement Data

There were no significant differences between the groups in any of the eye movement measures. Participants generally showed an attentional bias for the proximal spiders in the direction of their first EM. Three participants were excluded from the EM analysis due to missing data as a result of equipment failure, so there are 21 participants in the HFG and 17 in the LFG.

EM-direction. EM-direction bias scores (which were shown to not differ significantly from normal by a Kolmogorov-Smirnov test) were entered into a mixed design analysis of variance (ANOVA) with perceived proximity (proximal vs. distal) as a within-subjects factor and fear group (high vs. low) as a between-subjects factor (see Table 5.2 for means). The results showed a main effect of perceived proximity, $F(1, 36) = 13.63$, $p < .001$. Overall, participants directed their gaze more frequently towards the proximal spiders (55.7%) rather than distal spiders (48.1%). A one-sample *t*-test confirmed that this bias towards more proximal spiders was significantly greater than 50%, $t(37) = 2.57$, $p < .05$, with no significant difference from 50% for the more distal spiders, $t(37) = 1.21$, *ns*. The predicted fear group x perceived proximity interaction was not significant, $F(1, 36) = 1.85$, *ns*.

Fixation latency. Latency data that was more than 2 *SD*s above the mean were excluded as outliers (0.11%)[20]. A Kolmogorov-Smirnov test showed that the distribution of the data was not significantly different from normal. The data were entered into an ANOVA with one between-subjects factor of fear group (high vs. low) and two within-subjects factors of picture type (spider vs. rabbit) and perceived proximity (proximal vs. distal); see Table 5.2 for means. The results showed a significant picture type x perceived proximity interaction, $F(1, 36) = 4.15$, $p < .05$. Post hoc comparisons indicated that, in general, participants made faster initial EM to the distal rabbits ($M = 384$ ms) than to the proximal rabbits ($M = 423$ ms), $t(37) = 2.12$, $p < .025$, but there was no difference in latency of initial EM towards more

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[20] The same pattern of results is observed when data more than 3 *SD*s above the mean are excluded.

proximal (*M* = 406 ms) and more distal spiders (*M* = 425 ms), *t*(37) = 0.82, *ns*[21]. The predicted fear group x picture type x perceived proximity interaction was not significant, *F*(1, 36) = 1.90, *ns*.

Total dwell time. Dwell time bias scores (which Kolmogorov-Smirnov tests showed did not differ significantly from the normal distribution) were entered into and ANOVA with perceived proximity (proximal vs. distal) as a within-subjects factor and fear group (high vs. low) as a between-subjects factor (see Table 5.2 for means). The results showed no main effects or interactions. The predicted fear group x perceived proximity interaction was not significant, *F*(1, 36) = 1.30, *ns*.

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[21] The *t*-test results, for both the direction and latency data, remain when using a revised significance level via Bonferroni corrections ($p < .025$).

Table 5.2 Summary of Eye Movement Data for each Fear Group

Picture Type	HFG *M*	HFG *SD*	LFG *M*	LFG *SD*
	EM-direction bias scores (%)			
Proximal Spider	56.78	17.81	54.69	7.60
Distal Spider	46.33	13.02	49.87	6.56
	Latency of initial fixations (ms)			
Proximal Spider	400.78	98.10	413.32	160.87
Proximal Rabbit	406.28	115.40	443.15	184.56
Distal Spider	409.21	164.92	443.79	209.27
Distal Rabbit	394.61	160.33	369.23	116.02
	Dwell time (ms)			
Proximal Spider	1777.20	401.50	1975.88	259.42
Proximal Rabbit	1806.78	369.39	1597.77	273.33
Distal Spider	1832.24	546.88	1783.85	191.84
Distal Rabbit	1809.08	566.16	1871.60	189.56
	Dwell time bias scores (%)			
Proximal Spider	49.47	10.90	55.30	7.28
Distal Spider	50.38	15.28	48.77	5.24

Psychophysiological Data

The proximal spider stimuli elicited a potentiated startle eye blink response in participants in the HFG.

Startle eye blink response. Three participants were not included in this analysis due to missing data as a result of equipment failure, so there were 19 participants in the HFG and 19 in the LFG. The mean eye blink magnitude data are displayed in Table 5.3 below. The data were entered into an ANOVA with one between-subjects factor of fear group (high vs. low) and three within-subjects factors of picture type (spider vs. rabbit), perceived proximity (proximal vs. distal), and time of startle probe (300 ms vs. 3000 ms). The results showed a main effect of perceived proximity, $F(1, 36) = 8.14, p < .01$ and time, $F(1, 36) = 9.44, p < .01$. There was also significant fear group x picture type x perceived proximity interaction, $F(1, 36) = 4.09, p = .05$.

To explore this interaction, two further ANOVAs were performed. First an ANOVA for the proximal pictures alone, with one between-subjects factor of fear group (high vs. low) and one within-subjects factor of picture type (spider vs. rabbit). The results showed a significant main effect of fear group, $F(1, 36) = 4.39, p < .05$, and a significant fear group x picture type interaction, $F(1, 32) = 4.19, p < .05$. Post hoc tests showed that the HFG had larger eye blink magnitude to the more proximal spiders than the LFG ($t(36) = 2.25, p < .05$), with no difference between the groups in the magnitude of their startles to the proximal rabbits, $t(36) = 1.75$, *ns*, see Figure 5.1. A similar ANOVA carried out for the distal pictures alone showed no significant main effects or interactions.

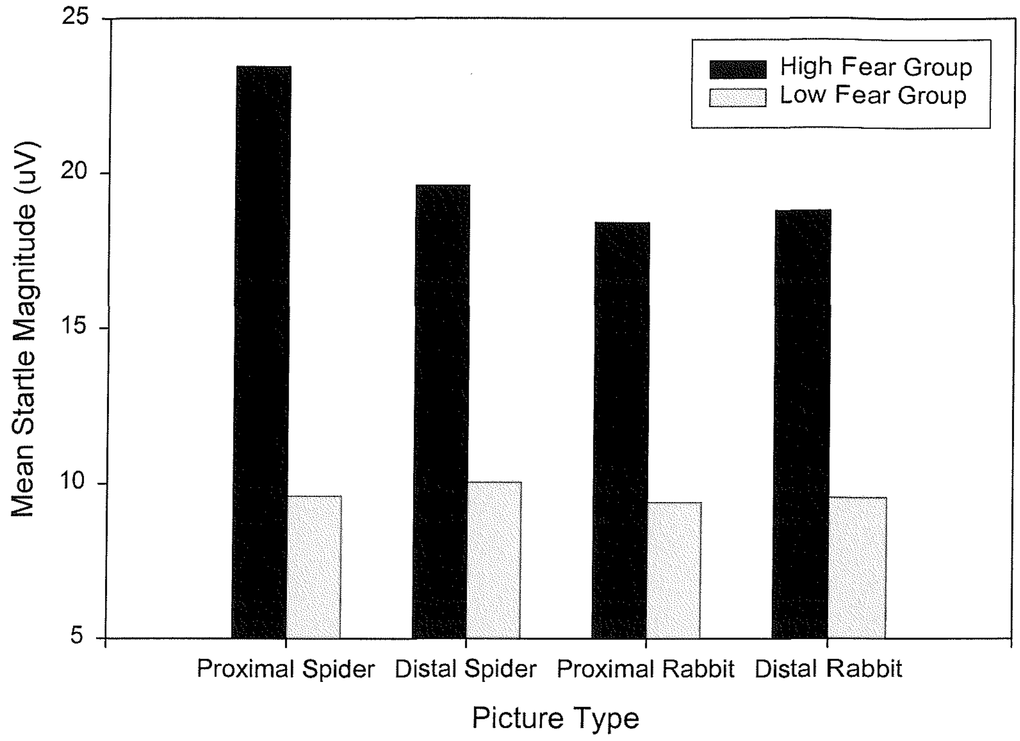

Figure 5.1 Mean eye blink startle magnitudes (μv)

Skin conductance responses (SCR). Two participants were not included in this analysis due to missing data as a result of equipment failure, so there were 19 participants in the HFG and 20 in the LFG. The mean SCR data are displayed below in Table 5.3. The data were log transformed to normalise the distribution (see Bradley et al., 2001). The logged data were entered into and ANOVA with perceived proximity (proximal vs. distal) and picture type (spider vs. rabbit) as a within-subjects factor and fear group (high vs. low) as a between-subjects factor. The results showed no significant main effects or interactions. The predicted fear group x picture type x perceived proximity interaction was not significant, *F*(1, 37) = 1.01, *ns*, neither was the fear group x picture type interaction which has been in previous studies (*F* < 1).

Table 5.3 Mean Physiological Responses

	HFG		LFG	
Picture Type	*M*	*SD*	*M*	*SD*
	Startle eye blink magnitudes (μv)[22]			
Proximal Spider 300 ms startle	22.5	25.2	9.0	13.8
Proximal Spider 3000 ms startle	24.4	25.1	10.2	8.9
Proximal Rabbit 300 ms startle	16.0	18.4	9.1	12.7
Proximal Rabbit 3000 ms startle	20.8	21.4	9.7	9.8
Distal Spider 300 ms startle	17.2	17.9	9.1	11.7
Distal Spider 3000 ms startle	22.0	23.1	11.0	10.3
Distal Rabbit 300 ms startle	16.8	18.5	8.0	10.7
Distal Rabbit 3000 ms startle	20.8	23.7	11.1	11.6
	SCR magnitudes (uS)			
Proximal Spider	0.05	0.08	0.06	0.09
Proximal Rabbit	0.04	0.08	0.02	0.07
Distal Spider	0.06	0.12	0.02	0.06
Distal Rabbit	0.04	0.08	0.01	0.06

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[22] The pattern of the results is the same when using a log transformation to normalise the distribution.

Perceived Proximity Rating Task

Overall, participants rated the proximal pictures as being perceived to be closer than the distal pictures.

The subjective perceived proximity rating data were entered into a mixed design ANOVA with one between-subjects factor of fear group (high vs. low) and two within-subjects factors of picture type (spider vs. rabbit) and perceived proximity (proximal vs. distal); see Table 5.4 for means (Kolmogorov-Smirnov tests showed the distribution of the data not to differ significantly from normal). The results showed significant main effects of perceived proximity, $F(1, 39) = 607.21$, $p < .001$, and picture type, $F(1, 39) = 31.15$, $p < .001$. These were subsumed within a significant perceived proximity x picture type interaction, $F(1, 33) = 14.22$, $p < .01$. Post hoc comparisons showed that the manipulation of perceived proximity was effective for each stimulus type; participants found the proximal spiders to be significantly closer than the distal spiders ($t(40) = 20.82$, $p < .001$) and the proximal rabbits to be significantly closer than the distal rabbits ($t(40) = 23.45$, $p < .001$)[23]. The interaction suggests that this difference between proximal and distal stimuli is greater for the rabbit pictures than the spider pictures.

Fear/Anxiety Rating Task

Participants in the HFG rated both the spider pictures in general as being more fear/anxiety provoking than participants in the LFG. The proximal spider pictures were also rated as significantly more fear/anxiety provoking than the distal spider

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[23] These remain significant when using a Bonferroni corrected significance level.

pictures by the HFG. These participants also rated the rabbit pictures in general as being more fear/anxiety provoking than the LFG.

The fear/anxiety rating data were entered into a mixed design ANOVA with one between-subjects factor of fear group (high vs. low) and two within-subjects factors of picture type (spider vs. rabbit) and perceived proximity (proximal vs. distal); see Table 5.4 for means. Kolmogorov-Smirnov tests showed the distribution of the data not to differ significantly from normal. The results showed main effects of fear group, $F(1, 39) = 189.09, p < .001$, picture type, $F(1, 39) = 323.35, p < .001$, and perceived proximity, $F(1, 39) = 75.00, p < .001$. There were also significant fear group x picture type, $F(1, 39) = 187.03, p < .001$, fear group x perceived proximity, $F(1, 39) = 14.71, p < .001$, and picture type x perceived proximity, $F(1, 39) = 69.88, p < .001$, interactions. These were subsumed within a significant fear group x picture type x perceived proximity interaction, $F(1, 39) = 19.35, p < .001$.

In order to explore this interaction, two further ANOVAs were performed. First, an ANOVA for the spider pictures alone was performed, with one between-subjects factor of fear group (high vs. low) and one within-subjects factors of perceived proximity (proximal vs. distal). For these pictures, there were a significant main effects of both perceived proximity, $F(1, 39) = 92.49, p < .001$, and fear group, $F(1, 39) = 239.83, p < .001$. These were subsumed within a fear group x perceived proximity interaction, $F(1, 39) = 21.31, p < .001$. Post hoc contrasts[24] showed that the HFG gave higher fear/anxiety ratings than the LFG for both the proximal ($t(39) = 20.17, p < .001$) and distal spiders ($t(39) = 9.13, p < .001$). The interaction indicates that the group differences in rating was larger for the proximal than distal spiders.

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[24] Which remain when using Bonferroni corrections of the significance level ($p < .025$).

A similar ANOVA performed for the rabbit pictures showed only a main effect of fear group, *F*(1, 39) = 12.21, *p* = .001. The HFG gave higher fear/anxiety ratings for the rabbits (*M* = 1.6) than the LFG (*M* = 1.1).

Table 5.4 Perceived Proximity and Fear/Anxiety Rating Means

	HFG		LFG	
Picture Type	*M*	*SD*	*M*	*SD*
	Perceived Proximity Rating Task			
Proximal Spider	1.19	0.27	1.62	0.57
Proximal Rabbit	1.59	0.70	1.76	0.60
Distal Spider	4.62	1.09	4.96	1.15
Distal Rabbit	5.54	0.90	5.76	0.78
	Fear/Anxiety Rating Task			
Proximal Spider	6.52	0.60	2.03	0.82
Proximal Rabbit	1.67	0.77	1.20	0.42
Distal Spider	4.38	1.46	1.28	0.45
Distal Rabbit	1.51	0.43	1.06	0.13

Correlations

Correlations were calculated between the SPQ[25] and the eye movement, psychophysiological, and rating task measures for the whole sample. Increased SPQ scores were associated with higher ratings of fear/anxiety for the more proximal

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[25] Spearman's rho is used for these correlations as the SPQ scores are not normally distributed.

($r_s(41) = .81, p < .001$) and more distal ($r_s(41) = .75, p < .001$) spiders, and closer perceived proximity ratings for the more proximal spiders ($r_s(41) = -.44, p < .01$).

Other significant correlations between measures are reported. Greater eye blink startle magnitudes elicited by the more proximal spiders were associated with higher ratings of fear/anxiety of the more proximal spiders, $r(38) = .36, p < .05$. Greater eye blink startle magnitudes elicited by the more proximal spiders were also associated with closer perceived proximity ratings for the more proximal spiders, $r(38) = -.35, p < .05$. Similarly, greater eye blink startle magnitudes elicited by the more distal spiders were associated with closer perceived proximity ratings for the more distal spiders, $r(38) = -.34, p < .05$. Greater percentages of total dwell time spent looking at the more proximal spiders were associated with a greater percentage of first EM made towards the more proximal spiders, $r(38) = .40, p < .05$. Conversely, greater percentages of total dwell time spent looking at the more distal spiders were associated with a lesser percentage of first EM made towards the more proximal spiders, $r(38) = -.35, p < .05$. Finally, a greater rating of fear/anxiety of the more proximal spiders was associated with closer ratings of perceived proximity for the more proximal spiders, $r(41) = -.47, p < .01$.

Discussion

The main aim of this study was to assess how attentional allocation and physiological responses were affected by the perceived proximity of threatening stimuli. This was done by using a hybrid task in which eye movements, startle eye blinks, and SCRs were measured concurrently. A greater ratio between the sizes of proximal and distal pictures was used than in previous studies in an attempt make an assessment of the predictions, concerning the effect of increasing threat proximity, made from the various models discussed (e.g. Lang et al., 1997).

The results of the eye movement measures showed no significant differences between the high and low fear groups in their attentional responses to the spider cues. The physiological measures also showed no significant results for SCR. However, participants fearful of spiders demonstrated significantly larger startle eye blinks in response to auditory probes whilst viewing pictures of the proximally perceived spiders. No potentiation of startle eye blink was observed in this group for the distally perceived spiders or the rabbit stimuli, nor was there a potentiation of this response in the low fear group for the spider stimuli. In addition to eliciting a potentiated startle response in the high fear group, the proximally perceived spider stimuli elicited this response regardless of the time during picture viewing at which the auditory startle probe occurred. Startle reflex potentiation was observed in the HFG in response to probes irrespective of whether they were presented at 300 ms or 3000 ms into the picture viewing time. This result indicates that a degree of defensive activation is being elicited by proximally perceived threat, and that this defensive activation appears to be occurring rapidly. Distal threat did not elicit this defensive response. These results replicate the finding of Study 2. It also suggests that the lack of attentional biases in the eye movement measures is not due to the fact that the proximal spiders were not eliciting a different response than the distal spiders in the high fear group. Clearly, the proximal spiders were eliciting some degree of defensive activation in spider-fearful participants, as indicated by their potentiated startle response to these stimuli.

As was shown in the previous studies, the perceived proximity rating task indicated that the manipulation of size was successful in altering the participants' perception of the proximity of the stimuli. Overall, participants rated the proximally perceived stimuli as being closer than the distal ones. This occurred for both the spider and the rabbit stimuli. The fear/anxiety rating task showed that participants in the high fear group found the spider pictures to be more fear/anxiety provoking than the low fear group, with the more proximal spiders being the most fear/anxiety provoking of all. Interestingly, the high fear group also rated the rabbit pictures in general as being more fear/anxiety provoking than the low fear group. This is most likely due to the fact that the rabbit pictures were shown interspersed with the spider pictures, and the presence of the spider pictures made the spider-fearful participants more anxious/fearful in general.

The result of the startle eye blink measure does offer some support to the theoretical models based on animal research (e.g. Lang et al., 1997) that predict that proximal threat will be more likely to elicit a potentiated startle response. Lang et al. (1997) state that "clear evidence that the organism has changed to a defensive posture is first seen in the probe reflex response" (pg. 128). Indeed, the correlations showed that potentiated startle response to the proximal spiders are associated with greater fear/anxiety ratings and closer perceptions of perceived proximity. In addition to the proximally perceived threat stimuli eliciting this defensive response in the high fear group, the response appears to be a rapid one. The rapid processing of threat has been proposed by many (e.g. LeDoux, 1996; Öhman, 1997; Öhman & Mineka, 2001) and would explain the high fear group's potentiated startle response to the more proximally perceived spiders occurring regardless of whether the probe occurs 300 ms or 3000 ms into the viewing time. Studies by Globisch et al. (1999) and Merckelbach et al. (1995) have also demonstrated rapid defence activation for fear-relevant stimuli. However, the results of this study and the same result demonstrated in Study 2, are novel in that the potentiated startle is only found for fear-relevant stimuli which are perceived to be proximal, and not for fear-relevant stimuli which appear to be distal.

However, the defence cascade model also predicts that proximal threat should elicit increases in SCR, an effect not found here, or in the previous two studies taking this measure (Studies 2 and 3 did show increased SCRs in the HFG in responses to the spider pictures overall). This would seem to suggest that SCR measures are not as influenced by changes in the perceived proximity of a threat stimulus in the same way as the startle reflex.

The present study used a greater ratio between the size of the proximal and distal stimuli in an attempt to reveal clear differences in attentional and physiological responses between the fear groups and for the different perceived proximities of spider stimuli. A clear result was found for the magnitude of startle response in the high fear group whilst viewing the proximal spiders. Moreover, this confirms a similar effect observed in the original perceived proximity manipulation in Study 2. The fact that the high fear group did exhibit potentiated startles to the proximal spiders and not to the distal spiders does indicate that the stimuli are eliciting different responses. Therefore, we would also expect to see differences between them in the attentional measures. The lack of any attentional biases for spider cues in the HFG is surprising not only because these are predicted by various cognitive models of anxiety (e.g. Lang et al., 1997; Öhman, 1994), but also because they have been found in previous eye movement studies (e.g. Hermans et al., 1999; Rohner, 2000). One factor which might perhaps account for the lack of clear results from the eye movement data is the length and design of the task. The hybrid design of the task, which was used in order to get concurrent measure of attentional allocation and physiological response, is over an hour in duration and involves the participants sitting in near darkness with nothing to do other than observe the stimuli. The studies which have found attentional biases have not intermixed the eye movement trials with trials assessing other measures. Perhaps, therefore, it may be useful to assess attentional allocation separately, which would also ensure a shorter task.

The following study addresses a slightly different issue than those assessed so far. It involves a different, and considerably shorter, task to see whether the distally and proximally perceived stimuli used throughout this thesis can affect the behaviour action tendencies of participants.

Chapter Six: Study 5: Behavioural Action Tendencies Elicited by Proximally and Distally Perceived Stimuli in Spider Fear

Abstract

The aim of this study is to examine the effects of perceived proximity on the behavioural action tendencies of high and low spider-fearful participants. This is done by using the manikin version of the affective Simon task. The results show that the proximally perceived spider stimuli elicited the active defence responses of slower approach and faster avoidance of spider cues in the spider-fearful participants. These results are consistent with predictions from models of defence behaviour (e.g. Fanselow, 1994; McNaughton & Gray, 2000).

Introduction

The aim of this study is to examine the effects of perceived proximity of spider stimuli on behavioural action tendencies in high and low spider-fearful participants. This is done in order to examine how perceived proximity affects directed approach and avoidance behaviours in response to threat cues. Previous studies in this thesis have examined how perceived proximity affects attentional and physiological (startle and SCR) responses. However, the models discussed previously also suggest that the perceived proximity of a threat stimulus can influence the directed behaviour of an individual.

To recap, many models have distinguished two types of defensive behaviours that can be activated by threatening stimuli (e.g. Blanchard & Blanchard, 1988; Fanselow, 1994; Lang, Bradley & Cuthbert, 1997; McNaughton & Gray, 2000). These models suggest that the type of defence behaviour activated depends on the proximity and intensity of the threat, and that each type of defence behaviour has different responses associated with it. As has been discussed before, the distinction is made between a vigilant assessment of risk demonstrated in response to distal threat and an active defensive response demonstrated in response to proximal threat has also been applied to work with humans. Lang, Davis and Öhman (2000) distinguish between anxiety, which they claim is a "generalised state of distress...often without organized functional behaviour" (pg. 144) and fear, which is defined as "a reaction to an explicit threatening stimulus with escape or avoidance being the outcome of cue proximity" (pg. 144). Furthermore, like Fanselow (1994), they claim that the type of defensive behaviour deployed is modulated by the "imminence of danger" (pg. 150). Lang, Bradley and Cuthbert (1997), based on the work of the Blanchards (1988) and Fanselow (1994), have modelled the outputs of the human defence system as a threat increases in intensity. According to their model, low-intensity threatening stimuli elicit attentional processing. With great threat intensity however, this oriented attention gives way to active defence behaviours. This process is seen by Lang et al. (1997) as a "staged transition from attention into action" (pg. 128).

Therefore, these models suggest that the behaviours elicited by threatening stimuli are dependent on how proximal and threatening these stimuli are perceived to be. Distal low-intensity threat stimuli will elicit passive assessment behaviours as the threat is processed, however proximal high-intensity threat will elicit active avoidance behaviours. So, how a threat stimulus is perceived, in terms of both proximity and valence, can influence the type of behaviour demonstrated.

The affective Simon task (AST) was first developed by De Houwer and Eelen (1998) in order to examine the implicit evaluation of affective properties of stimuli. The paradigm itself has already been discussed in detail in *Chapter One*. Results of studies using the AST (e.g. Tipples, 2001) have found that the reaction times of participants are faster when the correct response matched the valence of the stimulus, even if participants were instructed explicitly to ignore the valence of the stimulus.

As was discussed in *Chapter One*, De Houwer, Crombez, Baeyens and Eelen (2001) developed a version of the AST in which a valenced non-verbal response was used rather than a verbal one. Participants responded by making a manikin run towards or away from different classes of stimuli. The authors suggest that making the manikin run away is equivalent to an avoidance or escape response and that making the manikin run towards the stimulus is equivalent to approach behavioural tendencies. As would be expected from studies using the traditional affective Simon task, the results using this task have shown that participants were slower to make the manikin run away from positive words and towards negative words than vice-versa, even though the valence of the words was irrelevant to the task. De Houwer et al. (2001) interpreted these results as being consistent with the hypothesis that stimulus valence is ultimately linked to behavioural approach-avoidance tendencies.

Therefore, this paradigm provides a useful way of assessing both the implicit processing of the valence of a stimulus and the approach/avoidance behaviours it elicits. Although studies have used the manikin version of the affective Simon task and other similar tasks to investigate valence (e.g. de Jong, van den Hout, Rietbroek, & Huijding, 2003; Mogg, Bradley, Field, & De Houwer, 2003; Bradley, Field, Mogg & De Houwer, 2004), no study has examined how the behavioural tendencies are influenced by the perceived proximity of the stimulus. Thus, the present study investigated the proposal from the models based on animal research (e.g. Fanselow, 1994; Lang et al., 1997) that an important determinant of active defence behaviour is the perceived proximity of the threat stimulus.

Thus, the aim of this study is to examine the role perceived proximity plays in the demonstration of active approach/avoidance behaviour using the manikin version of the affective Simon task. As in previous studies, perceived proximity was manipulated by using different sizes of stimuli and presenting them to participants with distance and depth cues masked. It is expected that the larger stimuli will be perceived as being closer than the smaller stimuli, and, in the case of the spider stimuli, of greater threat intensity to the spider-fearful group.

In accordance with the theoretical models based on animal research (e.g. Fanselow, 1994), it is hypothesised that the proximal spider stimuli will elicit, in the high fear group, slower approach responses and faster avoidance responses compared to the rabbit control stimuli. This is because, according to the behavioural models, proximal threat is more likely to elicit active defence responses.

Method

Participants

Forty-four participants were recruited from undergraduates reading psychology at the University of Southampton. Potential participants filled out the Spider Phobia Questionnaire (SPQ; Watts & Sharrock, 1984) and selection criteria for participants were that they scored either 4 or less or 12 or more on the SPQ. Twenty-two participants were recruited into the low fear group (LFG) and 22 into the high fear group (HFG).

Materials and Apparatus

The stimuli for the affective Simon task consisted of 72 colour pictures, consisting of 18 spiders, 18 rabbits, 18 stool and 18 chair pictures (see *Appendix One* and *Three* for examples). Each picture was shown twice, once as a distally perceived stimulus and once as a proximally perceived stimulus making a total of 144 pictures. The spider and rabbit stimuli were the critical and control stimuli of interest in this study. The stool and chair stimuli were included as the category "furniture" for the AST design, see below. The pictures measured 12 cm by 12 cm; in the proximal stimuli the rabbit/spider took up about 100% of the picture area and in the distal stimuli the rabbit/spider took up about 11% of the picture area[26]. As the participants were seated 83 cm from the computer monitor, the proximally perceived pictures appeared to be approximately nine times larger than the distal ones. The proximal stimuli subtended 8.2° of visual angle and the distal stimuli subtended 2.7° of visual angle. The total stimulus set was shown twice during the affective Simon task (AST),

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[26] This is the same % as was used in Studies 1, 2, and 3 and not the same as in Study 4 which was carried out after this study.

once during each assignment. The AST also involved practice and buffer trials in which cat, hamster, stool and chair pictures were used, again shown in both proximal and distal perceived proximities. The stimuli for the valence and proximity ratings task were identical to those used in the affective Simon task. Each spider and rabbit picture was presented individually to the participant until they responded.

All three tasks were presented on a Mesh PC with a 17-inch monitor in indexed 256 colour palette. The AST was programmed in C++, whilst the two ratings task used Inquisit version 1.32 software. Responses to the affective Simon task were made using a MEL version 2 response box, whilst responses during the two rating tasks were made using a standard keyboard. Participants viewed the monitor down a black rectangular tunnel constructed in order to mask distance and depth cues in an attempt to aid the perceived proximity manipulation. This also ensured that all participants were seated 83 cm from the monitor.

Procedure

Participants first completed a consent form. The experimental tasks were presented in a fixed order for all participants. The first task was the AST, followed by the valence and perceived proximity rating tasks.

The AST consisted of two blocks, each of 72 trials. In each trial, a picture was presented individually in the centre of the screen with a stick figure manikin, approximately 18 mm high and 10 mm wide, appearing either above or below. Participants responded by pressing the up or down arrows on the response box, which moved the manikin up or down the screen, respectively. Each block had a different stimulus-response assignment. In Assignment 1, the participants were instructed to move the manikin towards animal pictures (i.e. the spider and the rabbit pictures) and away from the furniture pictures (i.e. the chair and stool pictures). In Assignment 2 these contingencies were reversed, participants were instructed to move the manikin away from animal pictures and towards furniture pictures. The order of the assignments was counterbalanced across participants and within fear groups. For each assignment, there were eight practice trials, in which four hamster/cat and four furniture pictures were presented, followed by two buffer trials and 72 test trials, in a new random order for each participant. Within each assignment, the picture type, perceived proximity condition, and the position of the manikin was counterbalanced to ensure that the approach/avoid instruction involved pressing one response button half the time and the other response button the rest of the time. This was done in order to avoid direct one-to-one mapping between the required response on each trial and the approach/avoid instructions. The furniture category (chairs and stools) was included in order that participants had to make the same response to the critical (spider) and control (rabbit) stimuli in each assignment. The data from trials presenting furniture pictures will not be included in the analysis.

Following the AST, participants completed the valence rating task and the perceived proximity rating task. The valence rating task consisted of 72 trials in which each spider and rabbit picture was presented individually in a new random order for each participant. The picture was presented in the centre of the screen and underneath it appeared a 9-point anchored rating scale. Each picture remained on screen until the participant responded, and then it was replaced by the next picture, with a 1000 ms inter-trial interval. The rating scale ranged from -4 (very unpleasant) to +4 (very pleasant) and participants were asked to press one of nine keys to indicate how pleasant or unpleasant they found each picture ("How pleasant or unpleasant do you find this picture?"). The perceived proximity rating task was identical except the 7-

point rating scale ranged from 1 (very close) to 7 (very far away), and participants were asked to press one of seven keys to indicated how close or far away they thought the animal in each picture was ("How close or far away do you think the animal in this picture is?"). This was identical to the perceived proximity rating tasks used in all the previous studies.

Upon completion of these computer tasks, participants completed the Spider Phobia Questionnaire (SPQ; (Watts & Sharrock, 1984) and were debriefed.

Results

Group Characteristics

The HFG had significantly higher scores on the SPQ, both at screening and at testing (see Table 6.1 for means and *t*-test results).

Table 6.1 Fear Group Characteristics

	HFG		LFG			
	M	*SD*	*M*	*SD*	*t*(42)	*p*
SPQ (screening)	17.91	3.94	2.59	1.42	16.71	< .001
SPQ (experiment)	19.23	3.13	3.50	2.56	18.24	< .001
Age (years)	19.64	1.22	20.50	1.90	1.80	*ns*
Gender ratio, m/f	2/20		4/18			

Affective Simon Task

Overall, participants in the high fear group were relatively faster to avoid and slower to approach the proximal spider pictures compared to those in the low fear group.

Reaction time data from trials with error were discarded (4.8%). Reaction times greater than three seconds were also discarded (0.12%; see De Houwer et al., 2001). One participant was also excluded because she had a mean reaction time of over three standard deviations ($M = 1366$ ms) from that of the mean sample reaction times ($M = 709$ ms, $SD = 112$ ms).

In order to examine the results, bias scores were calculated by taking the time to approach each picture condition away from the time taken to avoid each picture condition, see Table 6.2 for mean RTs and bias scores. Kolmogorov-Smirnov tests showed the distributions of these bias scores did not significantly differ from normal. Positive scores therefore indicate quicker to approach and a slower avoidance reaction times, and negative scores indicate a slower approach and quicker avoidance reaction times. According to De Houwer et al's (2001) interpretation of the affective Simon task, positive scores are expected to be elicited by stimuli of a positive valence and negative scores are expected to be elicited by stimuli of a negative valence.

These bias scores were entered into a mixed design analysis of variance (ANOVA) with one between-subjects variable of fear group (high vs. low) and two within-subjects factors of picture type (spider vs. rabbit) and perceived proximity (proximal vs. distal). The results showed a main effect of picture type, $F(1, 41) = 18.36, p < .001$, perceived proximity, $F(1, 41) = 5.522, p < .05$, and fear group, $F(1, 41) = 6.57, p < .05$. There was also a significant fear group x picture type interaction, $F(1, 41) = 8.18, p < .01$, and a significant perceived proximity x picture type interaction, $F(1, 41) = 4.74, p < .05$. These were subsumed within a significant fear group x picture type x perceived proximity interaction, $F(1, 41) = 4.64, p < .05$.

Two further ANOVAs were performed to examine this interaction. First, an ANOVA for the spider pictures, with perceived proximity (proximal vs. distal) and fear group (high vs. low) as independent variables. There were significant main effects of both fear group, $F(1, 41) = 9.15, p < .01$, and perceived proximity, $F(1, 41) = 8.96, p < .01$, and a significant fear group x perceived proximity interaction, $F(1, 41) = 4.54, p < .05$. Post hoc tests indicated that the HFG had a significantly lower bias score for the proximal spiders compared to the LFG ($t(41) = 3.62$, $p < 0.01$), with no difference between the groups for the distal spiders ($t(41) = 1.94$, *ns*), see Figure 6.1 below. A similar ANOVA carried out for the rabbit pictures showed no significant main effects or interactions.

Table 6.2 AST means (ms) and bias scores

		HFG		LFG	
Variables		*M*	*SD*	*M*	*SD*
Picture Type	Assignment	RTs to stimuli (ms)			
Proximal Spider	Approach	777.94	198.67	643.54	115.64
	Avoid	657.05	114.03	700.67	100.14
Proximal Rabbit	Approach	698.97	129.71	637.26	95.56
	Avoid	768.94	137.82	721.05	103.13
Distal Spider	Approach	736.66	165.50	637.38	81.74
	Avoid	715.23	151.59	711.26	95.48
Distal Rabbit	Approach	723.21	175.83	639.15	91.35
	Avoid	774.97	165.73	739.04	129.03
		Bias scores			
	Proximal Spider	-120.89	197.68	57.13	110.84
	Proximal Rabbit	69.97	124.12	83.79	86.58
	Distal Spider	-21.43	209.87	73.89	83.46
	Distal Rabbit	51.76	120.09	99.89	90.43

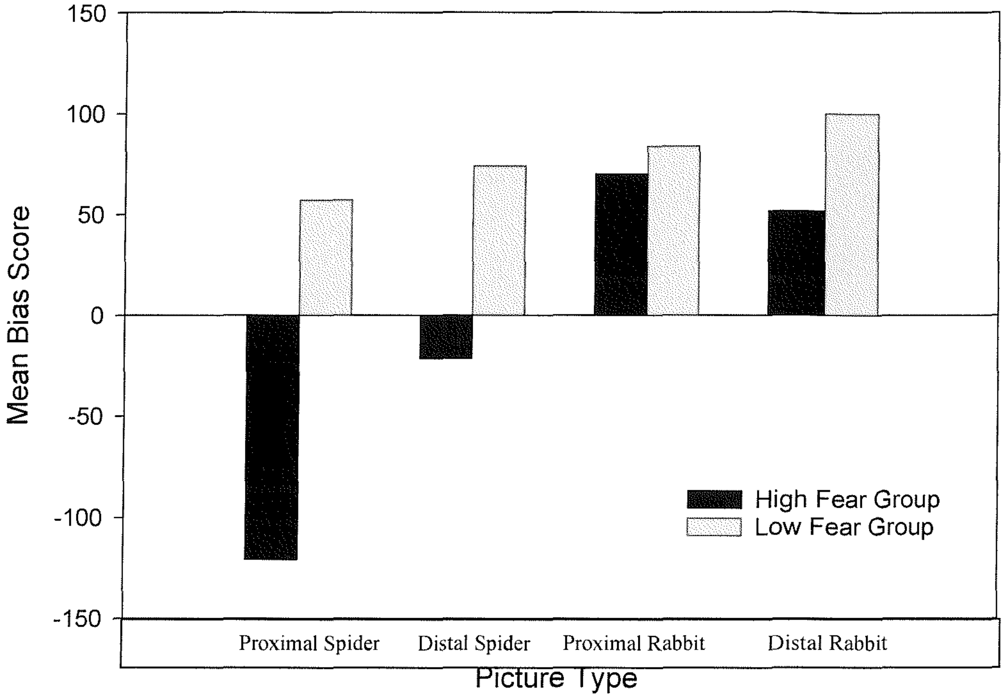

Figure 6.1: Mean bias scores

Perceived Proximity Rating Task

Overall, participants rated the proximal pictures as being perceived to be closer than the distal pictures.

The perceived proximity ratings, which Kolmogorov-Smirnov tests showed that the distributions of these data did not differ significantly from normal, were entered into a repeated measures ANOVA, with two within-subjects variables of perceived proximity (proximally versus distally perceived) and picture type (spider versus rabbit), and one between-subjects variable of fear group (high versus low fear group); see Table 6.3 for means. The results showed main effects of fear group, $F(1, 42) = 12.40, p < .01$, picture type, $F(1, 42) = 50.62, p < .001$, and perceived proximity, $F(1, 42) = 672.11, p < .001$. These were subsumed within a significant fear group x picture type x perceived proximity interaction, $F(1, 42) = 6.47, p < .05$.

Two further ANOVAs were performed to look at this interaction. First, an ANOVA was carried out for the HFG, with perceived proximity (proximal vs. distal) and picture type (spider vs. rabbit) as independent variables. This ANOVA showed a significant main effects of picture type, $F(1, 21) = 60.37, p < .001$, and perceived proximity, $F(1, 21) = 279.01, p < .001$, and a significant picture type x perceived proximity interaction, $F(1, 19) = 10.68$, $p = .01$. A similar ANOVA carried out for the LFG only showed a significant main effect of perceived proximity, $F(1, 19) = 370.17$, $p < .001$.

Post-hoc tests indicated that, in general, participants found the proximal stimuli (both spiders ($t(42) = 19.72, p < .001$) and rabbits ($t(42) = 27.61, p < .001$)) to be closer than the distal stimuli (both spiders and rabbits). Participants in the HFG also rated the proximal spiders as being closer than the proximal rabbits, ($t(21) = 5.86$, $p < .001$) and the distal spiders as being closer than the distal rabbits, ($t(21) = 7.86, p < .001$)[27]. The interaction indicates that this difference was somewhat larger for the distal stimuli.

Valence Rating Task

Overall, the HFG found the proximal and distal spider pictures more unpleasant than the LFG. They also found the proximal rabbits more pleasant than the LFG.

The valence rating data (which were found not to differ significantly from normal) were entered into a mixed design ANOVA with one between-subjects factor of fear group (high vs. low) and two within-subjects factors of picture type (spider vs. rabbit) and perceived proximity (proximal vs. distal); see Table 6.3 for means. The

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[27] These post hoc results remain the same when using a Bonferroni corrected significance at the .0125 level.

results showed main effects of fear group, *F*(1, 42) = 12.40, $p < .001$, picture type, *F*(1, 42) = 50.62, $p < .001$, and perceived proximity, *F*(1, 42) = 672.11, $p < .001$. These were subsumed within a significant fear group x picture type x perceived proximity interaction, *F*(1, 42) = 6.47, $p < .05$.

Two further ANOVAs were carried out to assess this interaction. An ANOVA for the spider pictures alone was performed, with one between-subjects factor of fear group (high vs. low) and one within-subjects factors of perceived proximity (proximal vs. distal). For these pictures, there were significant main effects of both perceived proximity, *F*(1, 41) = 57.51, $p < .001$, and fear group, *F*(1, 41) = 87.38, $p < .001$. Post hoc contrasts showed that the HFG gave more unpleasant ratings than the LFG to both the proximal (*t*(42) = 9.39, $p < .001$) and distal spiders (*t*(42) = 8.47, $p < .001$).

A similar ANOVA performed for the rabbit pictures showed a main effect of perceived proximity, *F*(1, 41) = 32.24, $p < .001$, and a significant fear group x perceived proximity interaction, *F*(1, 41) = 4.63, $p < .05$. Post hoc tests indicated that the HFG rated the proximal rabbits as more pleasant than the LFG (*t*(42) = 2.25, $p < .017$)[28].

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[28] All post-hoc contrasts remain the same when using Bonferroni corrections of the significance level ($p < .017$).

Table 6.3 Subjective Rating Task Means

	HFG		LFG	
Picture Type	*M*	*SD*	*M*	*SD*
	Perceived Proximity Rating Task			
Proximal Spider	1.19	0.39	1.87	0.65
Proximal Rabbit	2.09	0.65	2.08	0.68
Distal Spider	3.83	1.02	5.03	0.52
Distal Rabbit	5.22	0.85	5.21	0.48
	Valence Rating Task			
Proximal Spider	-3.86	0.23	-1.31	1.25
Proximal Rabbit	2.06	0.73	1.48	1.18
Distal Spider	-3.09	0.63	-0.78	1.12
Distal Rabbit	1.53	0.72	1.23	0.99

Discussion

The aim of this study was to assess how the perceived proximity of fear-relevant stimuli affected the behavioural action tendencies of high and low spider-fearful participants. The results showed that the high fear group demonstrated more negative bias scores in response to the proximal spiders compared to the LFG. These negative bias scores indicated that these participants were faster to avoid and slower to approach the proximal spiders. Therefore, the behavioural response tendencies of participants, as measured by the AST, seem only to be affected by the proximally perceived fear-relevant stimuli.

The subjective rating task results provide further support for this interpretation of the AST. They indicated that the manipulation of perceived proximity, by changing the size of the stimuli, has been successful in altering participants' perceptions of proximity and threat value. The results from the perceived proximity rating task indicated that participants generally rated the proximal pictures as being closer than the distal ones. The perceived proximity of the stimuli also effected how participants evaluated their valence. The subjective valence rating task demonstrated that the spider-fearful participants rated the proximal and distal spider stimuli as being more negatively valenced than the low fear group. Therefore, participants perceived the proximal stimuli to be closer than the distal stimuli, and the high fear group perceived the spider stimuli to be more aversive than the low fear group. Interestingly though, it was only the proximally perceived spiders that elicited the bias scores in the HFG which differed significantly from the LFG.

The findings from the AST are in line with the models discussed, based on animal research (e.g. Fanselow, 1994; McNaughton & Gray, 2000), that draw a distinction between the types of defence behaviours elicited by proximal and distal threat. The results suggest that proximally perceived threat stimuli (i.e. the proximal spiders for the high fear group) elicited active defence behaviours.

In summary, the present study provides a unique assessment of how the perceived proximity of threat can influence the behavioural action tendencies of individuals. The results demonstrate that proximally perceived spider stimuli elicited the active defence behaviours of relatively faster avoidance and slower approach in spider-fearful participants. The distally perceived spiders did not significantly affect these responses, even in fearful participants. No published study has manipulated the threat value of stimuli in a manikin version of the AST, so it is interesting that the present study indicates that threat value does influence responses in this task. These results are in line with models based on work of animal behaviourists, which differentiate between the active defence behaviours elicited by proximal threat and the more behaviourally passive behaviours of attentional processing elicited by distal threat (e.g. Fanselow, 1994; Lang et al., 1997).

Chapter Seven: Study 6: The Allocation of Attention to Proximally and Distally Perceived Stimuli in Spider Fear – an Eye Movement Study

Abstract

The aim of this study was to examine the effect of perceived proximity on the allocation of attention to threat. This was done by measuring eye movements to picture pairs of distally and proximally perceived stimuli (spider and rabbit pictures), displayed for 3 s, in low and high spider-fearful participants. The results show the high fear group demonstrated significantly faster initial eye movements to the proximal spider pictures compared to the low fear group. Furthermore, the percentage of total time spent looking at the proximal spider pictures was significantly less for high fear participants than low fear participants. These results provide support for the some of the predictions made by cognitive models of anxiety (e.g. Mogg & Bradley, 1998).

Introduction

Models of fear and anxiety give rise to predictions as to how attention is initially allocated towards, and maintained by, threatening stimuli of different threat intensities and perceived proximities (e.g. Fanselow, 1994; Lang et al., 1997; Mogg & Bradley, 1998). The aim of this thesis has been to examine these predictions with reference to how physiological responses, attentional allocation, and behavioural action tendencies are influenced by the perceived proximity of threat stimuli. The results so far have been varied. It has been demonstrated that participants who are fearful of spiders exhibit a potentiated startle response whilst looking at pictures of proximal spiders, compared to non-fearful participants and relative to control stimuli (see Studies 2 and 4). The proximal spider stimuli have also been found to elicit behavioural action tendencies of faster avoidance and slower approach as measured by the AST in spider-fearful participants, relative to non-fearful participants and compared to control stimuli (see Study 5). Both proximal and distal spiders have been found to elicit increased SCR magnitudes in spider-fearful participants, relative to non-fearful participants and (see Studies 2 and 3). These results provide some support for models based in part on studies of animal behaviours (e.g. Fanselow, 1994; Lang et al., 1997; McNaughton & Gray, 2000) which predict that proximal threat is more likely to elicit active defence behaviours, such as escape behaviours and potentiated startle reflexes.

However, the results of the various attentional measures employed during the course of this thesis have been less clear-cut. The visual probe tasks used in Studies 1 and 2 did not find any differences between the fear groups. The eye movement measures in Study 3 indicated that the high fear group (HFG) had a greater tendency to direct their first eye movement towards spiders compared to the low fear group

(LFG), however there were no group differences for the latency or dwell time measures. Study 4 did not find any differences between the fear groups for any of the eye movement (EM) measures.

There have been countless studies which have found effects of attentional biases for high fear stimuli in fearful participants (see Mogg & Bradley, 1998 for review). For example, Mogg and Bradley (in press) found that spider-fearful participants had an initial attentional bias for spider pictures, compared to non-fearful participants and relative to control stimuli, using a visual probe task. Similarly, studies monitoring eye movements have also found differences in the viewing pattern of spider-fearful and non-fearful participants when viewing spider pictures (e.g. Hermans et al., 1999).

Two studies have examined how manipulating the intensity of threat influences initial attentional allocation. As was described earlier, both Mogg et al. (2000) and Wilson and MacLeod (2003) find evidence to suggest that increasing the threat value intensifies the initial attentional bias in anxious individuals. Other studies suggest that the initial attentional bias for threat can be overridden by avoidance of threat (e.g. Hermans et al., 1999; Mogg et al., in press; Pflugshaupt et al., in press; Rohner, 2002; Tolin et al., 1999).

The lack of consistent results for the EM measures in this thesis may be due to methodological issues. Studies 3 and 4 used a hybrid task which allowed for the concurrent measure of eye movements, startle and SCRs. However, other studies which have shown group differences in attentional biases have not inter-mixed trials in this way (e.g. Hermans et al., 1999). This suggests that it might be helpful to assess attention separately. This would also reduce the length of the testing session. It may also be helpful reduce the emphasis on the eye movements in order to reduce demand effects. This could be done by including a probe following the picture display to which participants are to respond, in a similar way to a visual probe task.

So far, no published study has directly addressed the issue of how the proximity of a threat influences the attentional responses it elicits. The aim of this study is to examine how the initial allocation and maintenance of attention towards threatening stimuli changes in perceived proximity. This is done by monitoring the eye movements made by high and low spider-fearful participants to distally and proximally perceived stimuli. The stimuli are the same as were used in the studies reported in the previous five chapters; namely pairs of proximally and distally perceived spider and rabbit pictures. Perceived proximity was again manipulated by using different sizes of stimuli and presenting them to participants with distance and depth cues masked. Biases in initial orienting were assessed, as in Studies 3 and 4, from the direction and latency of the initial shift in gaze in response to the paired pictures. Biases in the maintenance of attention were assessed, again as in previous studies, from the amount of time spent looking at each picture in the pair over the 3000 ms presentation time. In order to address the methodological issues discussed above, a probe was included after the picture display which participants were asked to classify. Also, only eye movements were recorded during this task, considerably reducing the length of the testing session.

Models based on animal research (e.g. Fanselow, 1994; Lang et al., 1997) suggest that the distal spider stimuli are more likely to capture and maintain the attention of the highly spider-fearful individuals, whilst the more proximally perceived spider pictures are more likely to be avoided from the outset. Cognitive models of anxiety (e.g. Mogg & Bradley, 1998) suggest that highly threatening stimuli are more likely to elicit initial orienting, accompanied by avoidance tendencies. This suggests that spider-fearful individuals will demonstrate enhanced initial orienting to the proximally perceived spider pictures, but that this initial attentional bias may give way to avoidance over the course of the presentation time.

Method

Participants

Forty participants were recruited from undergraduates reading psychology at the University of Southampton. Potential participants filled out the Spider Phobia Questionnaire (SPQ; Watts & Sharrock, 1984) and selection criteria for participants were that they scored either 4 or less or 12 or more on the SPQ. Twenty participants were recruited into the low fear group (LFG) and 20 into the high fear group (HFG).

Materials and Apparatus

The stimuli for the attentional task consisted of 36 colour picture pairs. There were two types of picture pair, 18 pairs were of a proximal spider paired with a proximal rabbit and the other 18 pairs were of a distal spider paired with a distal rabbit (see *Appendix Two* for examples). The pictures measured 12 cm by 12 cm; in the proximal stimuli the rabbit/spider took up about 100% of the picture area and in the distal stimuli the rabbit/spider took up about 2% of the picture area. As the participants were seated 83 cm from the computer monitor, the proximally perceived pictures appeared to be approximately 50 times larger than the distal ones. The proximal stimuli subtended 8.2° of visual angle and the distal stimuli subtended 1.2° of visual angle. The pairs were displayed 5.8cm between their inner edges (4° of visual angle). The attentional task also involved ten pairs of practice/buffer pictures. These were five pairs of a proximal cat paired with a proximal hamster and the other five pairs were of a distal cat paired with a distal hamster. In the two ratings tasks, which followed the attentional task, each of the pictures was shown individually.

The computer tasks were presented in a dark, electrically isolated and sound-proofed room, using an Evesham PC and a 17” VGA monitor running Inquisit version 1.32 software. Participants looked at the monitor down a black rectangular tunnel constructed in order to mask distance and depth cues in order to aid the perceived proximity manipulation. This also ensured that participants were seated approximately 83 cm from the monitor. Horizontal eye movements recorded during the visual probe task were measured using horizontal electrooculography (EOG). This was done in the same way as in Studies 3 and 4. The EOG activity was registered using two miniature EL254S Ag/AgCl surface electrodes (Biopac System, Inc) filled with Biopac electrode gel. These were attached to the outer canthus of each eye and the signal was amplified using a CED 1902 bio-amplifier with a time constant of 0.16 Hz and 30 Hz low pass filter. Data were collected at 510 Hz throughout the experiment by a Viglen PC running Spike2 version 3.17.

Procedure

Participants first completed a consent form. They were then seated and the electrodes to measure EOG were attached. The tasks were presented in a fixed order for each participant, first the attentional task, followed by the fear/anxiety rating task and the perceived proximity rating task.

In the attentional task, each trial started with a central fixation cross for 1000 ms, which was replaced by the display of a pair of pictures placed side by side for 3000 ms. Each of the 36 picture pairs were shown four times, making a total of 144 experimental trials. Immediately after the offset of the picture pair, an arrow probe (either ↑ or ↓) was presented until response or for a maximum of ten seconds. Participants were asked to press one of two response buttons as quickly as possible to classify the orientation of the arrow probe. The reason for requiring a response was to encourage participants to be attentive to the task whilst avoiding any emphasis on the picture content. Between trials there was an inter-trial interval of 1000 ms. Participants were instructed to look at the fixation cross at the start of each trial. Eye movement data were recorded from the onset of a picture pair until their offset. The task started with eight practice trials, followed by two buffer trials then the 144 experimental trials, presented randomly. On half of the trials for each perceived proximity, the spider stimulus was on the left and the rabbit stimulus was on the right, and vice versa for the other half of trials. The orientation and position of the critical stimulus was also balanced across trials, so that each appeared in each position with equal probability.

Following the attentional task, participants completed the fear/anxiety rating task and the perceived proximity rating task. The fear/anxiety rating task consisted of 72 trials in which each spider and rabbit picture was presented individually in a new random order for each participant. The picture was presented in the centre of the screen and underneath it appeared a 7-point anchored rating scale. Each picture remained on screen until the participant responded, and then it was replaced by the next picture, with a 1000 ms inter-trial interval. The rating scale ranged from 1 (not at all fearful/anxious) to 7 (very fearful/anxious) and participants were asked to press one of seven keys to indicate how fearful/anxious each picture made them feel ("How fearful/anxious does this picture make you feel?"). This task was the same as the one used in Study 4. The perceived proximity rating task was identical to the ones used in all the previous studies. The rating scale ranged from 1 (very close) to 7 (very far away), and participants were asked to press one of seven keys to indicated how close or far away they thought the animal in each picture was ("How close or far away do you think the animal in this picture is?").

Upon completion of these computer tasks, participants completed the Spider Phobia Questionnaire (SPQ; Watts & Sharrock, 1984) and were debriefed.

Preparation of the Eye Movement Data

Using the Spike2 3.17 programme, the EOG data were analysed to detect left and right eye movements (EM) in the same way as in Studies 3 and 4. First the data were exposed to a low pass filter at 20 Hz. A script programme was written and run using the Spike2 program in order to detect the eye movements during the attention task trials. This program used the following rules for identifying the left and right eye movements. An eye movement as measured by EOG presents as a peak. The initial slope to the peak is the initial movement and the final slope of natural decay away from the peak is the duration of the fixation. A true eye movement to a picture was defined as having an initial slope with a rate of change in mV over time of greater than or equal to 0.3 mV/s occurring in a time window of 0.06 s and a final slope with a rate of change in mV over time of greater than or equal to 1 mV/s in a time window of 0.1 s. There was also a minimum and maximum threshold for the eye movement peak of 0.04 and 0.4 mV, under or over which did not correspond to eye movements to the pictorial stimuli. In this way, responses recorded by the EOG too small or large to be eye movements to the pictures, and those slow eye movements related to sleep and fatigue were not included in the analysis. The dependent measures were the direction and latency of the initial fixation and the amount of time spent looking at each picture in a pair over the 3000 ms of its presentation (dwell time).

EM-direction bias scores were calculated in the same way as in Studies 3 and 4. These were obtained for each type of picture pair by calculating, for each participant, the number of trials in which the first eye movement was towards the critical stimulus, as a percentage of the number of trials of that particular type of pair with eye movements. There were no eye movement data collected from a mean of 3.75 (2.6%) trials in the LFG and 2.17 (1.45%) in the HFG. The number of missing trials did not differ significantly between the fear groups, $t(36) = 1.10$, *ns*. The EM-direction bias score for proximal spider pictures was the number of trials when the first EM was directed towards the proximal spider, divided by the total number of trials with EMs to proximal spider – proximal rabbit pairs. Therefore, a bias score greater than 50% indicated a preference to look first at proximal spiders rather than proximal rabbits, and a score of 50% reflects no bias. EM-direction bias scores were similarly calculated for distal spider – distal rabbit pairs.

Dwell time bias scores were calculated in the same way as described in Studies 3 and 4. These were calculated because the dwell time (ms) for each picture type was highly correlated across the whole sample and within each fear group (e.g. dwell time (ms) on spiders correlated negatively with that of rabbits $r(38) = -.96, p < .001$, for the proximal pictures, and $r(38) = -.95, p < .001$ for the distal pictures). Therefore, when the amount of time spent looking at the spider picture of a spider-rabbit pair was high, the amount of time looking at the rabbit picture of that pair was low. This means that picture type cannot be entered into an analysis of variance (ANOVA) as independent variables. For each trial, for each participant the total amount of time spent looking at either picture was calculated (maximum was 3000 ms). Trials where this was less than 1500 ms were set to missing data. There was a mean of 10.9 (7.57%) trials with missing data in the LFG and 6.22 (4.32%) in the

HFG. The number of missing trials did not differ significantly between the fear groups, *t*(36) = 1.82, *ns*. Dwell time bias scores were obtained for each type of picture pair by calculating, for each participant, the amount of time spent looking at the critical stimulus, as a percentage of the total time spent looking at either picture for that particular type of picture pair. Therefore, like the direction-bias score, a bias score greater than 50% indicated a preference to look longer at proximal spiders rather than proximal rabbits, and a score of 50% reflected no bias.

Results

Group Characteristics

The HFG had significantly higher scores on the SPQ, both at screening and at testing, compared with the LFG (see Table 7.1 for means and *t*-test results).

Table 7.1 Fear Group Characteristics

	HFG		LFG			
	M	*SD*	*M*	*SD*	*t*(38)	*p*
SPQ (screening)	18.05	4.74	2.58	1.43	13.9	< .001
SPQ (experiment)	19.15	4.61	3.00	1.86	14.5	< .001
Age (years)	20.40	3.44	20.55	2.7	1.0	*ns*
Gender ratio, m/f	0/20		1/19			

Eye Movement Data

The latency for the initial eye movement towards the proximal spiders was significantly faster in the high fear group compared with the low fear group. Furthermore, the percentage of the total time spent looking at the more proximal spiders was significantly lower in the high fear group compared to the low fear group. Participants showed a general bias to look initially at the more proximal spiders and a general bias to initially avoid the more distal spiders. The data from two participants were not included in this analysis due to equipment failure; therefore there are 18 participants in the HFG and 20 in the LFG.

EM-direction. EM-direction bias scores (which Kolmogorov-Smirnov tests showed did not differ significantly from the normal distribution) were entered into a mixed design analysis of variance (ANOVA) with perceived proximity (proximal vs. distal) as a within-subjects factor and fear group (high vs. low) as a between-subjects factor (see Table 7.2 for means). The results showed a main effect of perceived proximity, $F(1, 36) = 22.99, p < .001$. There were no significant main effects involving fear group ($F(1, 36) = 1.70$, *ns*) or any significant fear group x perceived proximity interaction ($F < 1$) . Overall, participants directed their gaze more frequently to the more proximal spiders relative to the proximal rabbits; a one-sample *t*-test confirmed that this bias towards the more proximal spiders (53.59% of trials) was significantly greater than 50%, $t(37) = 2.06, p < .05$. Furthermore, participants directed their gaze away from the more distal spiders towards distal rabbits; a one-sample *t*-test confirmed that this bias away from distal spiders (43.77% of trials) was significantly less than 50%, $t(37) = 5.86, p < .001$.

Fixation latency. Latency data that were more than 2 *SD*s above the mean were excluded as outliers (5.8%). Two further participants were then excluded as they had more than 18% of their data missing, therefore there were 17 participants in the HFG and 19 in the LFG. Kolmogorov-Smirnov tests showed that the distribution of the data did not differ significantly from normal. The data were entered into an ANOVA with one between-subjects factor of fear group (high vs. low) and two within-subjects factors of picture type (spider vs. rabbit) and perceived proximity (proximal vs. distal); see Table 7.2 for means. The results showed a significant main effect of perceived proximity, $F(1, 34) = 8.88, p < .01$, subsumed within a significant fear group x picture type x perceived proximity interaction, $F(1, 34) = 4.60, p < .05$, see Figure 7.1.

In order to explore this interaction, two further ANOVAs were performed. First, an ANOVA for the proximal pictures alone was performed, with one between-subjects factor of fear group (high vs. low) and one within-subjects factors of picture type (spider vs. rabbit). For these pictures, there was a significant fear group x picture type interaction, $F(1, 34) = 4.51, p < .05$. Post hoc tests showed that the HFG was significantly faster to look at proximal spider pictures than the LFG, $t(34) = 2.31, p < .025$. There was no difference between the groups in how fast they looked at proximal rabbit pictures, $t(34) = 0.06$, *ns*[29]. An ANOVA carried out for the distal pictures alone showed no significant main effects or interactions ($F < 1$).

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[29] All these post-hoc results remain the same when using Bonferroni corrected significance at the .025 level.

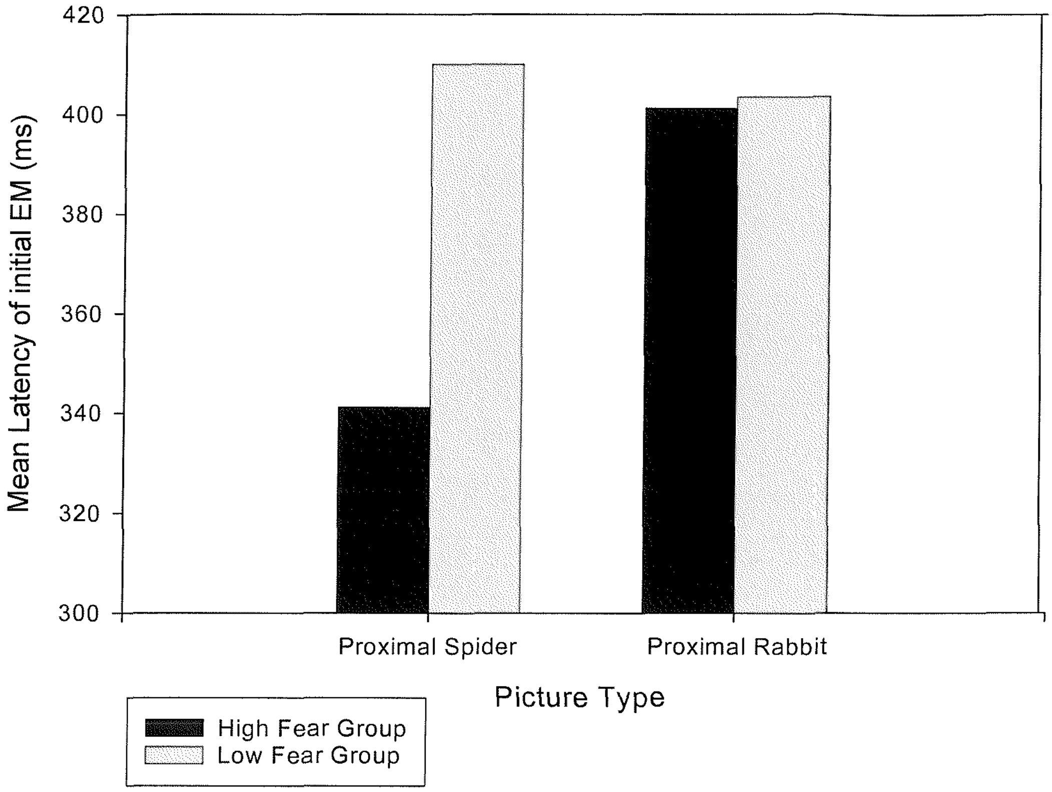

Figure 7.1 Mean latency of first eye movement (ms)

Total dwell time. Dwell time bias scores were entered into an ANOVA with perceived proximity (proximal vs. distal) as a within-subjects factor and fear group (high vs. low) as a between-subjects factor (see Table 7.2 for means of bias scores and in ms.). The results showed significant main effects of both fear group, $F(1, 36) = 4.46, p < .05$, and perceived proximity, $F(1, 36) = 9.54, p < .01$. These were subsumed within a significant fear group x perceived proximity interaction, $F(1, 36) = 4.63, p < .05$, see Figure 7.2.

Group contrasts showed that the HFG spent less time looking at proximal spiders than the LFG ($t(36) = 3.18, p < .01$). A one-sample t-test confirmed that this dwell time bias away from the more proximal spiders in the high fear group was significantly lower than 50%, $t(17) = 3.56, p < .01$[30]. In the LFG the dwell time bias scores did not differ significantly from 50%, $t(19) = 0.16$, *ns*. There was no difference between the groups in their dwell time on distal spiders ($t(36) = 1.51$, *ns*).

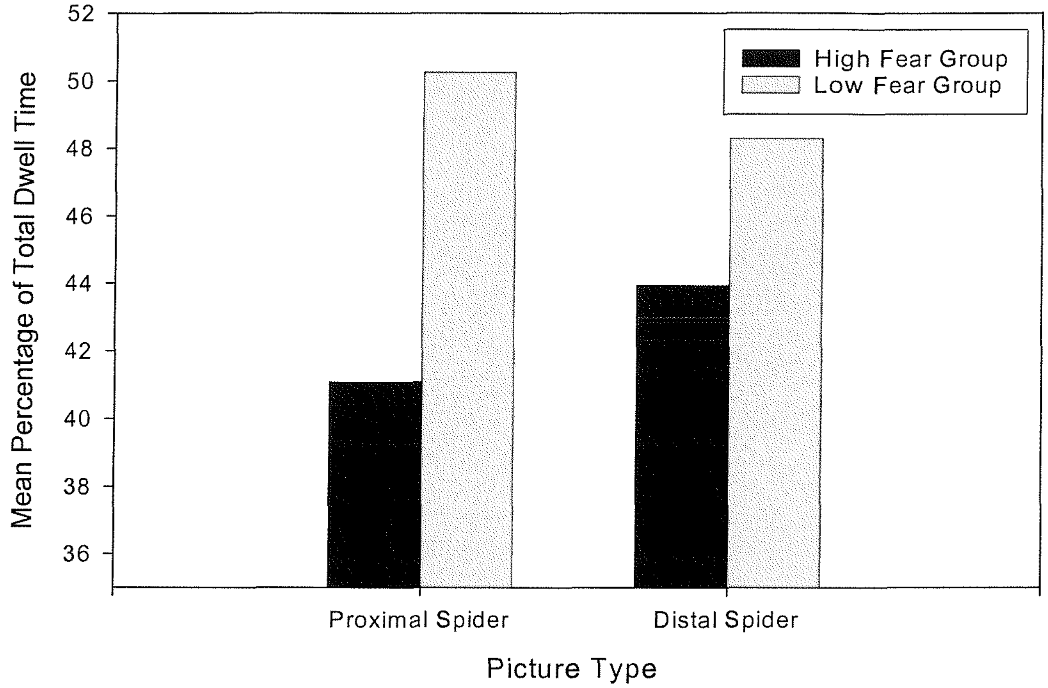

Figure 7.2 Mean percentage of dwell time spent on each picture by each fear group.

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[30] These remain significant when using a Bonferroni adjusted significance level of .0125.

Table 7.2 Summary of Eye Movement Data for each Fear Group

	HFG		LFG	
Picture Type	*M*	*SD*	*M*	*SD*
	EM-direction bias scores (%)			
Proximal Spider	52.02	13.13	55.16	8.75
Distal Spider	42.59	6.57	44.94	6.37
	Latency of initial fixations (ms)			
Proximal Spider	341.13	70.23	409.95	103.53
Proximal Rabbit	401.12	139.26	403.44	99.36
Distal Spider	358.90	95.67	381.43	92.93
Distal Rabbit	338.66	93.07	378.03	131.92
	Dwell time (ms)			
Proximal Spider	1069.92	278.39	1296.02	172.72
Proximal Rabbit	1537.22	293.91	1286.63	199.01
Distal Spider	1150.97	321.39	1266.51	105.37
Distal Rabbit	1475.92	345.40	1356.22	130.24
	Dwell time bias scores (%)			
Proximal Spider	41.08	10.62	50.25	6.95
Distal Spider	43.93	12.17	48.29	4.19

Perceived Proximity Rating Task

Overall, participants rated the proximal pictures as being perceived to be closer than the distal pictures.

The distributions of the subjective perceived proximity rating data were found not to differ from normal by Kolmogorov-Smirnov tests. The data were entered into a mixed design ANOVA with one between-subjects factor of fear group (high vs. low) and two within-subjects factors of picture type (spider vs. rabbit) and perceived proximity (proximal vs. distal); see Table 7.3 for means. The results showed significant main effects of fear group, $F(1, 38) = 5.56, p < .05$, perceived proximity, $F(1, 38) = 868.19, p < .001$, and picture type, $F(1, 38) = 29.88, p < .001$. There was also a significant perceived proximity x picture type interaction, $F(1, 38) = 29.88, p < .001$, and a fear group x perceived proximity x picture type interaction, $F(1, 38) = 5.41, p < .05$.

Two further ANOVAs were performed to look at this interaction. First, an ANOVA was carried out for the HFG, with perceived proximity (proximal vs. distal) and picture type (spider vs. rabbit) as independent variables, showed significant main effects of picture type, $F(1, 19) = 26.05, p < .001$, and perceived proximity, $F(1, 19) = 467.35, p < .001$, and a significant picture type x perceived proximity interaction, $F(1, 19) = 9.39, p < .01$. A similar ANOVA carried out for the LFG showed significant main effect of perceived proximity, $F(1, 19) = 409.34, p < .001$ and picture type, $F(1, 19) = 7.27, p < .05$.

Post-hoc tests indicated that the perceived proximity manipulation was successful for both spider and rabbit pictures. In general, participants found the proximal stimuli (both spiders, $t(39) = 22.77, p < .001$, and rabbits, $t(39) = 30.98, p < .001$) to be closer than the distal stimuli (both spiders and rabbits). Participants in the HFG also rated the proximal spiders as being closer than the proximal rabbits, ($t(19) = 3.34, p < .005$) and the distal spiders as being closer than the distal rabbits, ($t(19) = 4.96, p < .001$)[31]. The interaction indicates that this effect is somewhat larger for the distal stimuli.

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[31] These results remain the same when using a Bonferroni correction ($p < .0083$).

Fear/Anxiety Rating Task

The HFG rated the spider pictures in general as being more fear/anxiety provoking than the LFG. The proximal spider pictures were rated as significantly more fear/anxiety provoking than the distal spider pictures by the high fear group. The HFG also rated the rabbit pictures in general as being more fear/anxiety provoking than the LFG.

Kolmogorov-Smirnov tests showed that the fear/anxiety rating data did not differ significantly from the normal distribution. The data were entered into a mixed design ANOVA with one between-subjects factor of fear group (high vs. low) and two within-subjects factors of picture type (spider vs. rabbit) and perceived proximity (proximal vs. distal); see Table 7.3 for means. The results showed main effects of fear group, $F(1, 38) = 70.70, p < .001$, picture type, $F(1, 38) = 190.79, p < .001$, and perceived proximity, $F(1, 38) = 14.06, p < .01$. There were also significant fear group x picture type, $F(1, 38) = 67.98, p < .001$, fear group x perceived proximity, $F(1, 38) = 70.70, p < .001$, and picture type x perceived proximity, $F(1, 38) = 100.91, p < .001$, interactions. These were subsumed within a significant fear group x picture type x perceived proximity interaction, $F(1, 38) = 12.46, p < .01$.

In order to explore this interaction, two further ANOVAs were performed. First, an ANOVA for the spider pictures alone was performed, with one between-subjects factor of fear group (high vs. low) and one within-subjects factors of perceived proximity (proximal vs. distal). For these pictures, there were significant main effects of both perceived proximity, $F(1, 38) = 112.80, p < .001$, and fear group, $F(1, 38) = 78.00, p < .001$. These were subsumed within a fear group x perceived proximity interaction, $F(1, 38) = 14.56, p < 0.001$. Group contrasts showed that the HFG rated both the proximal ($t(38) = 9.05, p < .001$) and the distal spiders ($t(38) =$

6.88, $p < .001$) as more fear/anxiety provoking than the LFG. The interaction suggests that this effect is stronger for the proximal spiders.

A similar ANOVA performed for the rabbit pictures showed only a main effect of fear group, $F(1, 38) = 7.35, p < .05$. The HFG rated the rabbit pictures (M = 1.43) as being more fear/anxiety provoking than the LFG (M = 1.10), ($t(38) = 2.71, p < .001$)[32].

Table 7.3 Summary of Subjective Rating Task Means for each Fear Group

	HFG		LFG	
Picture Type	*M*	*SD*	*M*	*SD*
	Perceived Proximity Rating Task			
Proximal Spider	1.33	0.35	1.54	0.36
Proximal Rabbit	1.76	0.70	1.94	0.58
Distal Spider	4.71	0.96	5.46	1.07
Distal Rabbit	5.74	0.68	5.87	0.62
	Fear/Anxiety Rating Task			
Proximal Spider	6.16	1.11	2.54	1.41
Proximal Rabbit	1.50	0.69	1.12	0.25
Distal Spider	3.88	1.28	1.46	0.91
Distal Rabbit	1.36	0.40	1.07	0.15

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[32] All these post-hoc contrasts remain the same using Bonferroni corrections on the significance level.

Correlations

Correlations were calculated between the SPQ[33] and the eye movement and rating task measures for the whole sample. Increased SPQ scores were associated with less dwell time spent looking at proximal spiders ($r_s(38) = -.55, p < .001$) and a faster latency of initial EM towards proximal spiders ($r_s(38) = -.33, p < .05$). Increased SPQ scores were also associated with higher ratings of fear/anxiety for both proximal ($r_s(40) = .80, p < .001$) and distal ($r_s(40) = .77, p < .001$) spiders.

Discussion

The results indicate that the allocation of attention elicited by threatening stimuli is affected by the perceived proximity of the stimuli. The eye movement measures showed that the spider-fearful participants were faster to direct their gaze towards the proximal spiders than the non-fearful participants. This is consistent with enhanced initial orienting to proximal spiders in the high fear group. This bias in initial attentional allocation in the HFG varies during the time course of the 3000 ms presentation time. The HFG spent less time looking at proximal spiders than proximal rabbits, whereas the LFG showed no preference in gaze dwell time for either spiders or rabbits.

The results from the correlations are consistent with those from the ANOVAs. Participants with higher SPQ scores spent less of the total picture presentation time looking at the proximal spider stimuli. They also found both the distal and the proximal spider stimuli more fear/anxiety provoking.

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[33] A Kolmogorov-Smirnov test showed the distribution of the SPQ scores to differ significantly from normal. Therefore, Spearman's rho was used for these correlations.

The two subjective rating tasks indicate that the size manipulation of the stimuli was successful in altering participants' perception of proximity and threat intensity. Participants found the proximal pictures of both the spiders and the rabbits to be closer than the distal ones. The perceived proximity of the stimuli also affected how fear/anxiety provoking participants found them. The spider stimuli overall were rated as more fear/anxiety provoking by the highly fearful participants than the low fear group, and this effect was stronger for proximal spiders.

However, one of the eye movement measures did not distinguish between the two fear groups. Other studies have shown effects of threat stimuli in the direction of the initial eye movements in anxious participants (e.g. Bradley et al., 1999; Mogg et al., 2000). However, other studies have shown no differences in the direction of initial orienting between groups. For example, using a slightly different task, Hermans et al. (1999) found no difference in the viewing patterns of spider phobics and non-phobic controls in the first 500 ms of viewing paired spider and flower stimuli. In the latter study, both groups showed significantly more eye movements to the spider pictures than the flower pictures during the first 500ms of viewing time (see also Rohner, 2000).

Nevertheless, the results of the present study suggest that an increase in the perceived proximity of a threatening stimulus leads to faster initial orienting to that stimulus in spider-fearful individuals. This suggests that spider-fearful participants are able to process and respond to threatening stimuli quicker than participants who do not find the stimulus particularly threatening. This pattern of initial attentional allocation is consistent with the expectations from the cognitive models of anxiety (e.g. Öhman, 1994; Mogg & Bradley, 1998). It is also similar to other results, for example using a task in which participants' eye movement were monitored as the searched for spiders in scenes, Pflugshaupt et al. (in press) found that spider phobic participants were faster to detect spider stimuli than control participants.

LeDoux (1996) has proposed a pathway that may account for faster orienting towards threat in the high fear group. He discusses a pathway that goes directly from the thalamus to the amygdala and, by doing so, provides a "quick and dirty" analysis of simple stimulus features which allows for a rapid response to threat. So in participants who are fearful of spiders, the threat level elicited by the proximal spiders may lead to the activation of this pathway. This might result in quicker orienting to proximal spiders than is seen in the low spider-fearful participants.

Other studies have provided evidence of faster detection of fear-relevant stimuli in phobic individuals. For example, Öhman, Flykt and Esteves (2001) used a visual search paradigm in which participants had to search for discrepant fear-relevant (snakes or spiders) or fear-irrelevant (flowers or mushrooms) pictures. They found that participants, regardless of fear group, demonstrated enhanced detection of the fear-relevant stimuli. However, within fear groups there was further facilitation in the search for fear-specific stimuli. The latter finding is similar to that of this study that high fear participants showed faster latencies of eye movements when directing their gaze towards the proximal spider stimuli. Öhman et al.'s (2001) findings indicate a bias for evolutionary fear-relevant stimuli in participants (see Öhman, 1994; Öhman, 1996; Öhman & Mineka, 2001), but also an enhanced vigilance for these stimuli if they are of particular emotional relevance. The fact that this faster orienting is observed only for the proximal spider stimuli in the present study is not entirely consistent with Öhman et al.'s (2001) results, because they found enhanced detection of the threat stimuli in both the high and low fear groups, with further facilitation for fear-relevant threat stimuli. The use of different control stimuli in this study may perhaps explain this inconsistency.

Several models (e.g. Lang et al., 1997; McNaughton & Gray, 2000) differentiate between the pattern of attention elicited by threatening stimuli as they increase in proximity and threat intensity. As noted earlier, these models suggest that distal low threatening stimuli should elicit initial orienting and maintained attentional processing as the threat is assessed. Proximal highly threatening stimuli, on the other hand, should elicit rapid and sustained avoidance. Therefore, the enhanced orienting for proximally perceived threat demonstrated in this study is contrary to the predictions of the behavioural models based on animal research.

The patterns of attentional allocation in the high fear group changes during the time course of the picture presentation. Over the 3000 ms viewing time, the faster orienting observed in spider-fearful participants for the more proximal spiders subsequently gives way to active avoidance. As the more proximal spiders are rated by the high fear participants as being the most fear/anxiety provoking, these findings are in line with the predictions of cognitive models of anxiety (e.g. Mogg & Bradley, 1998). Highly threatening stimuli elicit an initial enhanced attentional bias followed by subsequent avoidance, in high fear participants, in order to escape the effects of this increased threat value. This finding is similar to the findings of Pflugshaupt et al. (in press). After being faster to detect the spider stimuli, the spider phobic participants then avoided them, compared to the control participants.

In summary, the results of the present study indicate that participants with a fear of spiders demonstrate enhanced initial orienting towards proximally perceived spiders. Specifically, they were faster to direct their gaze towards proximal spider stimuli. The HFG showed subsequent avoidance of the proximal spiders across the

3000 ms picture presentation time. These findings support some of the predictions of cognitive models of anxiety (e.g. Mogg & Bradley, 1998) and suggest that threat stimuli of different perceived proximities do have different effects on the allocation of attention.

Chapter Eight: Discussion

Introduction

The aim of this thesis was to examine the effect of a threat's perceived proximity on the cognitive and psychophysiological responses it elicits. This chapter will present a summary of the results of the six studies carried out, which are written up in detail in the preceding chapters. This review will also include a discussion of the various methodological issues raised during the course of this thesis, and how they may have impacted upon the results. The findings will then be discussed in relation to the predictions made by the various models of fear and anxiety. Finally, there will be a discussion of further work and some general conclusions to the thesis.

Review of Results

The results of the six studies will now be combined and reviewed in order to demonstrate the overall pattern of results concerning each of the measures assessed.

Attentional Measures

Studies 1 and 2 used visual probe tasks, whilst Studies 3, 4 and 6 used eye movement recordings to examine how the perceived proximity of a threat stimulus affects attentional allocation.

Visual Probe Tasks (Studies 1 & 2). Neither of these tasks demonstrated a difference between the fear groups in their responses to the spider stimuli. In Study 1 a visual probe task with a 200 ms SOA was used, similar to that used in a study by Mogg and Bradley (in press). However, unlike their study, the spider-fearful participants did not show an attentional bias for spider stimuli. Similarly in Study 2, which employed a visual probe task with a 300 ms and 3000 ms SOA, there was no difference in reaction times to probes between the high and low spider-fearful participants. This lack of group differences is surprising given that many models predict that stimuli should elicit differential attentional responding in people who find them threatening compared to non-fearful individuals (e.g. Mogg & Bradley, 1998; Öhman, 1994; Williams et al., 1997). Indeed, many studies using the visual probe task have demonstrated an initial attentional bias in fearful/anxious individuals for negative/threatening stimuli (see Mogg & Bradley, 1998 for review).

There are some methodological issues which may help explain the lack of predicted results in these studies. The visual probe task in Study 2 was the second task that participants undertook as it followed the psychophysiological recording task. It also used the same stimuli as had already been shown, for 6 seconds each, in the physiological recording task, which took about 45 minutes to complete. These tasks were presented in this fixed order because previous research had indicated that physiological measures such as SCRs were very susceptible to habituation (e.g. Bradley M. et al., 1993). The combined effects of having just completed a long and boring task (the participants were only required to watch the pictures, not make any responses in the physiological recording task) and having already been exposed to all the stimuli may have contributed to the lack of predicted results in the visual probe task. However, the visual probe task was the first task administered in Study 1. Yet, this visual probe task only used a single SOA of 200 ms. A limitation of this task was that it only provides a "snapshot" measure of the attentional bias at a fixed point in time. Therefore, it may be that 200 ms is not the ideal duration for revealing the attentional bias. The eye movement (EM) measures of subsequent studies provide a much more thorough examination of attentional allocation which encompasses the entire time course of the stimulus' presentation. This may therefore account for the lack of results in Study 1.

Eye Movement Measures (Studies 3, 4 & 6). Studies 3 and 4 involved a hybrid task designed to allow for the concurrent assessment of physiological responses (startle eye blink and skin conductance) and eye movements. This task therefore involved paired picture trials, during which EMs were monitored, interspersed with single picture trials, many of which involved an auditory startle probe, to assess startle eye blinks and SCRs. In Study 3, the HFG made more initial eye movements towards the spider stimuli relative to rabbit stimuli, compared to the LFG. However, none of the other EM measures (i.e. latency of initial EM, dwell time) in Study 3, or indeed any of the EM measures in Study 4, demonstrated differences between the fear groups, let alone between the different perceived proximities of stimuli. However, there are again certain methodological issues which may help account for this. The hybrid task used in these studies lasted over an hour and also did not require any response from the participants. Indeed, many reported fatigue and boredom to the experimenter upon completion of the task. In fact, the eye movement measures indicated that many participants were actually falling asleep during parts of the experiment. When participants are exposed to long and boring tasks they appear to stop attending as closely to the stimuli, and may therefore react less naturally, and less predictably, to them. It appears that eye movements may be particularly susceptible to this.

It is in Study 6 that predicted results were observed. This study differs from Studies 3 and 4 because eye movements were the only measure being assessed. Therefore, the task was considerable shorter and was not interspersed with trials to assess physiological measures (i.e. the individual picture trials involving an auditory startle probe). In addition to this, participants were also asked to respond to probes which followed the pictorial stimuli. This was done in an attempt to reduce demand effects by reducing the emphasis on eye movements. The results not only demonstrated differences between the fear groups in their attentional allocation, but also that the perceived proximity of the spider stimuli influenced the attentional responses of the HFG. The results of this study were consistent with expectations from cognitive models (e.g. Mogg & Bradley, 1998; Öhman, 1996). Specifically, that spider-fearful participants demonstrated faster initial orienting towards proximal fear-related stimuli and subsequently spent less of the viewing time looking at them, compared to non-fearful participants.

Psychophysiological Measures

Studies 2, 3 and 4 measured the startle eye blink magnitudes to auditory startle probes and SCRs of high and low spider-fearful participants whilst they observed pictures of proximally and distally perceived spiders and rabbits.

Startle Eye Blinks (Studies 2, 3 & 4). In both Studies 2 and 4, spider-fearful participants demonstrated a potentiated startle response whilst viewing the pictures of proximal spiders. This potentiated startle response was both rapid and sustained, in that it was observed in response to startle probes regardless of how long into the picture viewing time the probes occurred (300 ms or 3000 ms). Only in Study 3 were potentiated startle magnitudes observed in the HFG for all spider pictures, regardless of perceived proximity.

For the most part, these results provide some support for the predictions of models based on animal research (e.g. Lang et al., 1997; McNaughton and Gray, 2000). The fact that the proximal threat stimuli were found in 2 out of 3 studies to elicit a potentiated startle response in spider-fearful participants indicates that these stimuli are eliciting a defensive response, which the distal stimuli were not. Also, the finding that this startle probe potentiation, elicited by the proximal threat in Studies 2 and 3, occurs regardless of the probe time gives some support to the idea that this kind of threat is being processed rapidly (e.g. Öhman, 1994; Öhman & Mineka, 2001)

Skin Conductance Responses (SCRs; Studies 2, 3 & 4). The results of Studies 2 and 3 demonstrated that the spider pictures in general elicited greater SCRs in highly spider-fearful participants. However, in study 4 no significant results were found for the SCRs at all.

The fact that, within the HFG, SCRs do not seem to differentiate between the perceived proximities of spider stimuli in Studies 2 and 3, whilst the startle reflex in Studies 2 and 4 does, raises some questions. It may be that the SCR measure is simply not as sensitive as the startle reflex in detecting defensive activation. Indeed, Lang et al. (1997) do claim that "clear evidence...(of) a defensive posture is first seen in the probe reflex response" (pg. 128). Another possibility is that SCRs may operate on a lower threshold, and so are more readily elevated by distal threat than the startle reflex.

Behavioural Measures

It is only in Study 5 that the behavioural action tendencies elicited by proximally and distally perceived stimuli were examined, using an Affective Simon Task. Nevertheless, the results are clearly in line with the predictions of models based on animal research (e.g. McNaughton & Gray, 2000). Participants in the spider-fearful group were relatively quicker to avoid and slower to approach the proximal spiders, relative to the rabbit pictures and compared to the LFG. Therefore, it appears that proximal threat is capable of eliciting active defence behavioural tendencies in fearful participants, in this case faster avoidance and slower approach.

Perceived Proximity Ratings

The central question examined in this thesis is how perceived proximity affects the cognitive and physiological responses elicited by a threatening stimulus. The issue of proximity of a threat is central to the theoretical models based on animal research (e.g. Fanselow, 1994; Lang et al., 1997) in determining the type of defence behaviour elicited. Cognitive models of anxiety (e.g. Mathews & Mackintosh, 1998; Mogg & Bradley, 1998) also suggest that an increase in the threat value of a stimulus will influence attentional allocation. By making a threat stimulus appear closer, the threat value of that stimulus should also increase. Therefore, it is important that the experimental manipulation of perceived proximity was successful.

Perceived proximity was manipulated by using different sizes of stimuli and, in all studies except Study 4, by having participants view the computer monitor down a black tube which masked distance and depth cues. In Study 4 the distance cues were masked by using a dark testing room and covering all the furniture (e.g. computers, psychophysiological amplifiers etc.) in black cloth. Across the six studies the exact size, and therefore the visual angle subtended by, the proximal and distal stimuli changed, see Table 8.1 below. This altered in studies 4 and 6 because of the concern that the lack of predicted results in the attentional measures in Studies 1, 2 and 3 might have been due to this manipulation not being sufficiently strong. Therefore, in Studies 4 and 6 the difference in size between proximal and distal pictures was increased. However, this strengthening of the manipulation did not seem to be more influential as the proximally perceived spiders in both Study 2 and Study 4 elicited a similar pattern of potentiated startle responses in the HFG. Also, neither Studies 1 and 2, nor Study 4, produced the predicted effects in the attentional measures.

Table 8.1 Perceived Proximity Comparisons Across Studies

Study	Participants' distance from screen (cm)	Approximate area taken up by Proximal Animals (cm)	Visual Angle Subtended by Proximal Animals (°)	Approximate area taken up by Distal Animals (cm)	Visual Angle Subtended by Distal Animals (°)	Approx. number of times bigger proximal are than distal.
1 Visual probe	83	12 x 12	8.2	4 x 4	2.7	9
2 Startle/SCR & Visual Probe	83	12 x 12	8.2	4 x 4	2.7	9
3 Hybrid Task	83	12 x 12	8.2	4 x 4	2.7	9
4 Hybrid Task	200	22 x 22	6.3	3.1 x 3.1	0.9	50
5 AST	83	12 x 12	8.2	4 x 4	2.7	9
6 Eye Movements	83	12 x 12	8.2	1.7 x 1.7	1.2	50

Each of the six studies included a subjective rating task in which participants were shown each of the stimuli individually and asked to rate how close or far away they thought the animal was. This task was included to assess the success of the perceived proximity manipulation. The results have demonstrated that the manipulation is successful, all the participants of the six studies rating the proximal pictures as being closer than the distal ones, for both the spider and the rabbit pictures.

In Studies 1, 2 and 4 the difference in perceived distance between the distal and proximal pictures was somewhat larger for the rabbit stimuli than the spider stimuli. Rabbits were selected as control stimuli because, like spiders, they are animate creatures capable of sudden, rapid and unpredictable movement. However, unlike spiders, they are unlikely to be feared by the vast majority of people. They are also fairly similar in colour and texture to spiders, and so it was not too difficult to form matched pairs. However, because rabbits are larger than spiders in real life, a rabbit which appears to be the same size as a spider will also appear to be further away from the viewer than the spider. Therefore, the results of the rating task in Studies 1, 2 and 4 are perhaps not surprising.

In Studies 3, 5 and 6, participants in the HFG rated both the proximal and the distal spiders as being closer than the proximal and distal rabbits (with this difference being somewhat larger between the distal pictures). This may be due to both the real size of rabbits and spider, and also the fact that these participants are fearful of the spider pictures and not the rabbit pictures. Indeed, in Studies 3 and 4, self-reported spider fear, as reflected by SPQ scores, was positively correlated with perceived proximity ratings of the spider stimuli. Mathews and Mackintosh (2004) conducted a study looking at participants' memories of certain aspects of emotional scenes. They found that anxiety-prone participants remembered negative emotional pictures as if they were closer (with less of an extended background) than other pictures. Perhaps a similar process is occurring here which accounts for this "closer" perception of fear-relevant stimuli.

Nevertheless, the results of the subjective rating tasks, used in each study to assess the manipulation of perceived proximity, indicated that it was successful, regardless of the exact size of, or ratio between, the stimuli. For both the rabbit and the spider stimuli, the proximal pictures were rated by all participants as being perceived to be closer than the distal stimuli.

Evaluative Ratings

The six studies also included some form of subjective evaluative rating task, in which participants were shown each of the stimuli individually and asked to rate how the animal in each picture made them feel. The exact scale used varied across the six studies; in Studies 1 and 2 participants were asked about threat value, in Studies 3 and 5 they were asked about pleasant/unpleasantness and, in Study 3 alone, emotional arousal, and Studies 4 and 6 they were asked about fear/anxiety. This was done in an attempt to see if one particular question was better than another. In general the results of these various tasks have been similar, with the spider-fearful participants finding the spider stimuli more aversive than the LFG, and the more proximal spiders more aversive than the more distal ones (Studies 1, 2, 3, 4, 5 and 6).

In several studies aversive ratings of the spider pictures have correlated positively with other measures, such as potentiated startle responses to spiders (Studies 2 and 4) and SCRs to spiders (Studies 2 and 3). In Studies 4 and 6, both of which asked about feelings of fear/anxiety, the spider-fearful participants also rated the rabbit stimuli as more fear/anxiety provoking than the LFG. This may be due to the fact that the rabbit and spider pictures are shown intermixed, one after the other. Therefore, the spider-fearful participants had already been exposed to many spider pictures which may have increased their feelings of fear and anxiety in general, and so influenced their ratings of the rabbit stimuli. In both of these studies, the HFG's ratings of the spider stimuli were still significantly greater than their ratings of the rabbit stimuli. This effect may have been magnified by the type of rating question. It only occurred when the participants were asked to rate how fearful/anxious the pictures made them feel, and not when they were asked how threatening or how pleasant/unpleasant they found each picture. Asking about their feelings of fear and anxiety may elicit a more subjective appraisal, whilst asking about the threat value or unpleasantness of a picture may result in a more objective appraisal. Nevertheless, the spider stimuli were rated, on average, as more aversive by the spider-fearful group, compared to the non-fearful group, in all of the studies, and this seems to be intensified for the proximal spiders.

Theoretical Implications

The studies presented in this thesis have explored how perceived proximity affects the cognitive, physiological and behavioural responses elicited in humans by threatening stimuli. Predictions as to the effect of a threat's perceived proximity have been generated from various models of fear and anxiety, which suggest that responses should change in fearful participants as a fear-relevant stimulus appears to be getting closer.

The results of several of the studies support the prediction that proximal and distal threat stimuli elicit different cognitive, psychophysiological and behavioural responses. The results of the studies suggest that a distal threat stimulus elicits, in fearful individuals, an increase in SCRs which do not differ from those elicited by the proximal threat stimuli (Studies 2 and 3). Proximal threat also elicits faster initial attentional allocation and a subsequent bias to look away from the threat stimuli (Study 6), a potentiated startle reflex (Studies 3 and 4), and behavioural tendencies of relatively faster avoidance and slower approach (Study 5) in fearful individuals. In the next section the predictions made by the models based on animal research (e.g. Fanselow, 1994; Lang et al., 1997; McNaughton & Grey, 2000) will be discussed in relation to the relevant results of this thesis. Following that, the predictions extrapolated from the various cognitive models (e.g. Mogg & Bradley, 1998; Öhman, 1996) will be discussed in relation to the related findings.

Implications for Models based on Animal Research

According to the theoretical models based on animal research (e.g. Fanselow, 1994; Lang et al., 1997; McNaughton & Gray, 2000), an increase in the proximity of a threat stimulus should lead to a switch from a behaviourally passive but hypervigilant phase to more active behaviours associated with defensive activation. The results of the studies provide a degree of support for these predictions.

The models based on animal research predict that distal threat will not elicit active defence behaviours, such as a potentiated startle response or escape behaviours. According to Fanselow (1994), distal threat will elicit the post-encounter stage of defensive activation, which includes freezing. Freezing is cited by Lang et al. (2000) as one of the behaviours in the "defensive immobility" class of defensive responses. McNaughton and Gray (2000) also suggest that distal anxiety-provoking threat leads to behavioural inhibition. The results from several of the studies provide support for these predictions. The distal threat stimuli did not elicit a reliable potentiated startle response (Studies 2 and 4) or the behavioural tendencies of faster avoidance and slower approach (Study 5) in participants in the high fear group.

These models also predict that distal threat will elicit sensory processing and risk assessment behaviours. However, the results do not provide support for this prediction. There was no evidence of preferential attentional processing of the distal spider stimuli in the high fear group (relative to the low fear group) in any of the attentional measures (i.e. the visual probe tasks used in Studies 1 & 2, or eye movement measures assessed in Studies 3, 4 & 6).

The models based on animal research (e.g. Fanselow, 1994; Lang et al., 1997; McNaughton & Gray, 2000) predict that proximal threat should elicit a loss of the attentional processing in favour of an increased readiness to engage in active defence behaviours. Some evidence for this increased readiness has been demonstrated by the studies. The proximal threat elicit a rapid and maintained potentiated startle response in two out of three studies (Studies 2 and 4) and also elicited the behavioural action tendencies of faster avoidance and slower approach (Study 5). These results suggest that responses to proximal threat involved some degree of defensive activation that would enable the individual to escape from or avoid the proximal threat.

Lang et al. (1997) also predict that proximal threat stimuli should elicit greater SCR magnitudes than more distal threat stimuli. However, this effect was not found in the studies, spider-fearful participants demonstrated greater SCRs to the spider pictures in general compared to the control stimuli and relative to the low fear group in Studies 2 and 3. This may perhaps suggest that SCRs are operating on a different and lower threshold of threat value than the startle response and the behavioural action tendencies. This would mean that the level of threat elicited by the distal spiders in the HFG is sufficient to elicited greater SCR magnitudes, but not to elicit a reliable potentiated startle response or the behavioural action tendencies associated with avoidance.

The results of the EM measures of Study 6 indicated that the spider-fearful participants made faster initial eye movements towards the proximal spiders than the low fear participants. This result is at odds with the predictions of the models based on animal behaviour, which predict a loss of attention in favour of active avoidance (e.g. Lang et al., 1997).

Therefore, the results of this thesis provide limited support for the predictions of models based on animal research. Most notable is the fact that the proximal threat stimuli elicit a potentiated startle response (Studies 2 & 4) and behavioural tendencies of avoidance (Study 5) in the high fear group, providing support for the idea that proximal threat elicits defensive activation. However, there is no support for the prediction that distal threat elicits enhanced attentional processing. Rather, the results suggest that it is proximal threat which elicits faster initial orienting responses (Study 6).

As has been stated above, Lang et al. (1997) suggest that an inhibition of the startle reflex is a sign of attentional allocation towards the stimulus. Equally, they suggest that a potentiated startle response demonstrates a switch into a defensive posture. However, the results suggest that proximal threat elicits both enhanced initial attentional allocation *and* a rapid and sustained potentiated startle response in the high fear group. Lang et al. (2000) suggest that "startle potentiation begins in the context of freezing and vigilance" (pg. 150). The change from a vigilant mode with no active behavioural tendencies to an active defensive one is obviously a gradual process, occurring over a period of time as a threat stimulus is approaching. So, there may be an area of crossover in which attention is still being focused on the approaching threat while, at the same time, a defensive activation is beginning to take place. Therefore, one possibility is that the proximal threat used in the studies may be eliciting responses in this intermediary phase between vigilance and active defence and avoidance.

Another possibility is that the different perceived proximities of threat stimuli are tapping into a fear mechanism with different thresholds for outputting different responses. Therefore, both the distal and proximal spider stimuli reliably elicit increased SCR responses in the fearful participants. However, the proximal spider stimuli are of sufficient threat value to elicit an additional set of responses. These involve faster initial orienting followed by subsequent avoidance in gaze direction, a potentiated startle response, and the behavioural action tendencies of avoidance.

Implications for Cognitive Models

Predictions as to the effect of an increase in proximity of a threat stimulus can be extrapolated from cognitive models of anxiety (e.g. Mogg & Bradley, 1998). These models make predictions concerning the effect of threat value on attention. They predict that an increase in threat value will lead to enhanced initial attention, which may then give way to active attentional avoidance. Other cognitive models also predict that highly threatening stimuli may have an advantage for attentioanl processing (e.g. Mathews & Mackintosh, 1998; Öhman, 1994). Based on the predictions of these models, it can be suggested that an increase in the perceived proximity of a threat will also lead to an increase in its threat value, and so also lead to changes in attentional allocation.

The results of the EM measures of Study 6, which go against the predictions of the models based on animal research (e.g. Lang et al., 1997), do agree with expectations from cognitive models of anxiety (e.g. Mathews & Mackintosh, 1998; Mogg & Bradley, 1998). These models predict that highly threatening stimuli will lead to a stronger initial attentional bias. Studies which have manipulated threat value in ways other than perceived proximity have found a similar effects (e.g. Mogg et al., 2000; Wilson & MacLeod, 2003). This rapid response to threat also is in line work done looking at the preconscious processing of threat information (e.g. LeDoux, 1996; Öhman & Mineka, 2001). The idea of a "fear module", sensitive to innate threat stimuli, which has fast direct access to the amygdala may also explain the rapid potentiated startle observed in the spider-fearful participants in response to the more proximal threat. Indeed, other researchers have found evidence for this rapid elicitation of a defensive response (e.g. Globisch et al., 1999; Merckelbach et al., 1995), although the findings in this thesis are unique in that the rapid and sustained startle response occurred only for proximal threat.

The spider-fearful participants in Study 6 subsequently spent less time looking at the more proximal spiders than the rabbit stimuli. Cognitive models of anxiety also suggest subsequent avoidance of highly threatening stimuli, such as in the vigilance-avoidance hypothesis of Mogg and Bradley (1998). Other studies have also found that fearful or anxious participants subsequently avoid looking at threatening stimuli (e.g. Hermans et al., 1999; Mogg et al., in press; Pflugshaupt et al., in press; Rohner, 2002; Tolin et al., 1999). However, the present results are unique in revealing that this pattern of attentional allocation, initial enhanced vigilance and subsequent avoidance, occurs in response to proximal, rather than distal, threat.

Therefore, the results of Study 6 do support the predictions extrapolated from the various cognitive models discussed. In particular, that an increase in threat value, such as an increase in perceived proximity, leads to enhanced initial attentional allocation and subsequent avoidance in fearful participants. However, it is important to note that the attentional measures used in Studies 1, 2 and 4 did not support these predictions. However, as has been discussed, there are various methodological issues which may account for this. Furthermore, several cognitive models (e.g. Mogg & Bradley, 1998; Williams et al., 1997) also suggest that distal threat stimuli should also influence attentional allocation. However, evidence of attentional processing of the distal spiders by the high fear group was not observed in the majority of the attentional measures. This suggests that the faster initial orienting and subsequent avoidance elicited by the proximal threat will not be elicited unless the threat stimulus reaches a certain threshold of threat value. An increase in perceived proximity may be only one way in which a threat can elicit this response.

To summarise, the results as a whole indicate that the perceived proximity of a threat stimulus does influence the responses, attentional, behavioural and physiological, it elicits. The individual findings concerning the various measures provide some support for the predictions of both cognitive models and models based on animal research. However, many questions remain, and certain predictions from both types of model are not supported. Nevertheless I believe that, if the results are taken as a whole, they offer more support to the predictions of the behavioural models (e.g. Blanchard & Blanchard, 1988; Fanselow, 1994; Lang et al., 1997) than those of the cognitive models (e.g. Mogg & Bradley, 1998; Mathews & Mackintosh, 1998). The physiological and behavioural data strongly point towards the activation of active defence behaviours in favour of attentional processing in responses to proximal threat. I believe that, were it possible to examine these responses in humans to an actual approaching threat, the evidence of initial attentional processing observed in Study 6 would not occur. Rather, by the time the threat was proximal, fearful individuals would be not be looking at it, but rather for ways to escape.

Avenues of Further Work

This thesis has raised many questions which require further investigation before any firm conclusions can be drawn. Further research is required in order to determine whether the proximal threat stimuli were eliciting some intermediary stage between vigilance and assessment of a threat and the active defensive action to escape it. This may be achieved by using a different manipulation of perceived proximity. As only pictures were used in these studies, the perceived proximity manipulation has a limit to how ecologically valid it can be. As many of the models were based on research in animals, where behaviours were observed in response to the approach of real predators, an examination of responses more akin to reality might mean that proximal threat will elicit the total defensive response that such models predict. Although, as the rating tasks indicated, the manipulation of perceived proximity using pictures was successful, a more potent proximal threat may still be achievable within an experimental setting. For example, video footage of real spiders and control stimuli could be constructed in which the animals walk towards the camera. The physiological responses and attentional allocation of high and low spider-fearful participants could then be assessed at different time points during the stimulus' approach. This would allow for a more realistic study of the effects of threat proximity on cognitive and psychophysiological responses. The use of virtual reality could also lead to a more potent perceived proximity manipulation, allowing the approach of the stimuli to be extremely realistic.

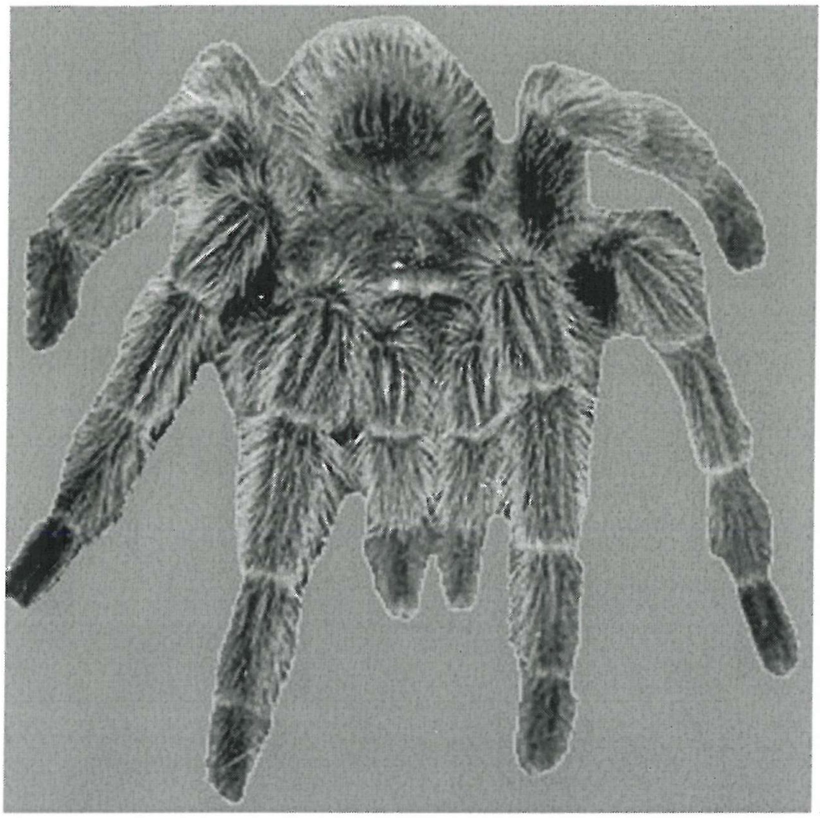
Another interesting finding has been the apparently rapid responses that the proximal spiders have elicited in the spider-fearful participants. The potentiated startle response was observed in the spider-fearful participants regardless of how early into the picture viewing time the startle probe was presented. The attentional measures also indicated spider-fearful participants make faster initial eye movements towards the more proximal spiders. These results have been linked to the theoretical models of Öhman (1996) and the neurobiological work of LeDoux (1996) which explain how the rapid transfer and processing of threat-related information can lead to an individual responding to a threat before s/he is even consciously aware of it. To explore these issues further it would be interesting to use the distal and proximal stimuli developed in this thesis to examine whether proximal threat does elicit a truly nonconscious activation of defence responses. The stimuli could be presented to high and low spider-fearful participants under conditions of backward masking. This would enable the measurement of both startle responses and SCR to the stimuli when they are not open to the conscious processing of the participants. The models suggest that the proximal threat stimuli will be more likely to be processed preconsciously and therefore that they should elicit greater potentiated startle reflexes and SCRs under subliminal presentation conditions.

General Conclusions

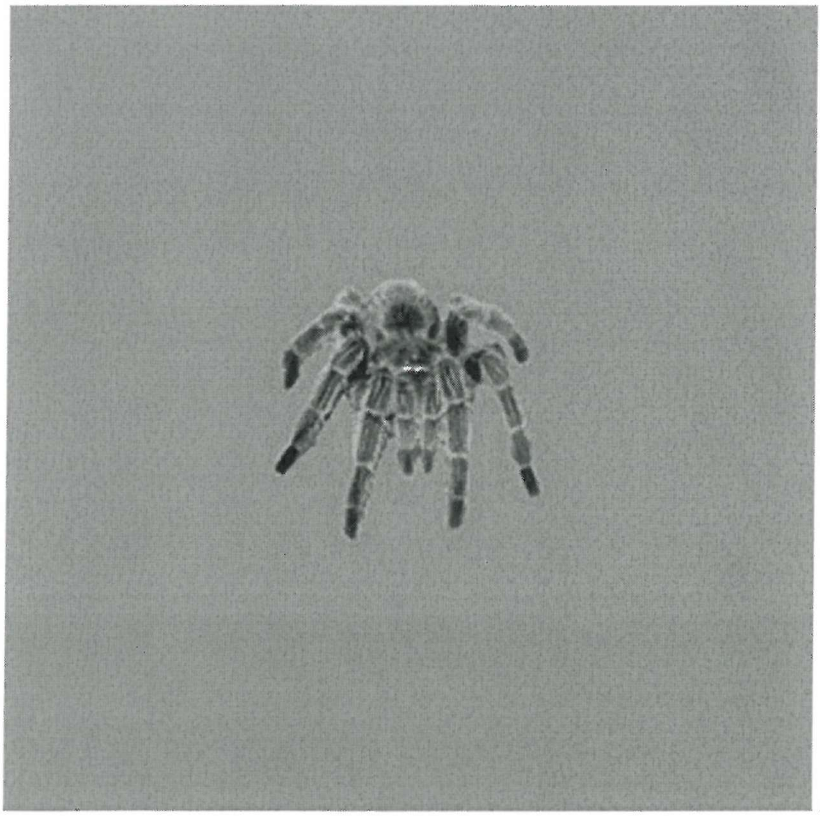
The main aim of this thesis was to examine the cognitive and psychophysiological responses elicited by threat stimuli at different perceived proximities. This was done in relation to the various predictions from models of fear and anxiety. Although these models are based on research in very different fields, they nevertheless have many similarities. As was predicted by both types of model, the results from several studies suggest that the responses elicited by proximal threat in high fear individuals are different from those elicited by distal threat. The distal threat stimuli used in these studies elicited increased arousal, but no behavioural action tendencies or reliable attentional biases and potentiated startle responses. These responses provide some support to models based on animal behaviour (e.g. Fanselow, 1994; Lang et al., 1997) which predict that a distal threat will elicit a behaviourally passive response. However, the vigilant behaviours predicted by these models were not reliably observed. In several studies, the proximal threat stimuli elicited a potentiated startle response and behavioural action tendencies of relatively faster avoidance and slower approach, as well as increased arousal. These behaviours are consistent with some predictions of the behavioural models, which predict that proximal threats elicit active defence behaviours (e.g. Lang et al., 1997; McNaughton & Gray, 2000). However, the proximal threat stimuli also elicited faster initial attentional orienting followed by subsequent avoidance in gaze dwell time. This result is partly consistent with cognitive models (e.g. Mogg & Bradley, 1998; Öhman, 1994), which predict that highly threatening stimuli will lead to an initial attentional bias which may be followed by subsequent avoidance. Given the various predictions of the models, the fact that the proximal threat stimuli elicit behaviours consistent with both defensive activation and attentional processing suggest that they may be tapping into a cross-over process from a stage of vigilance to one of defensive avoidance, or perhaps they are activating a fear mechanism with different thresholds for outputting different cognitive and psychophysiological responses.

Appendices

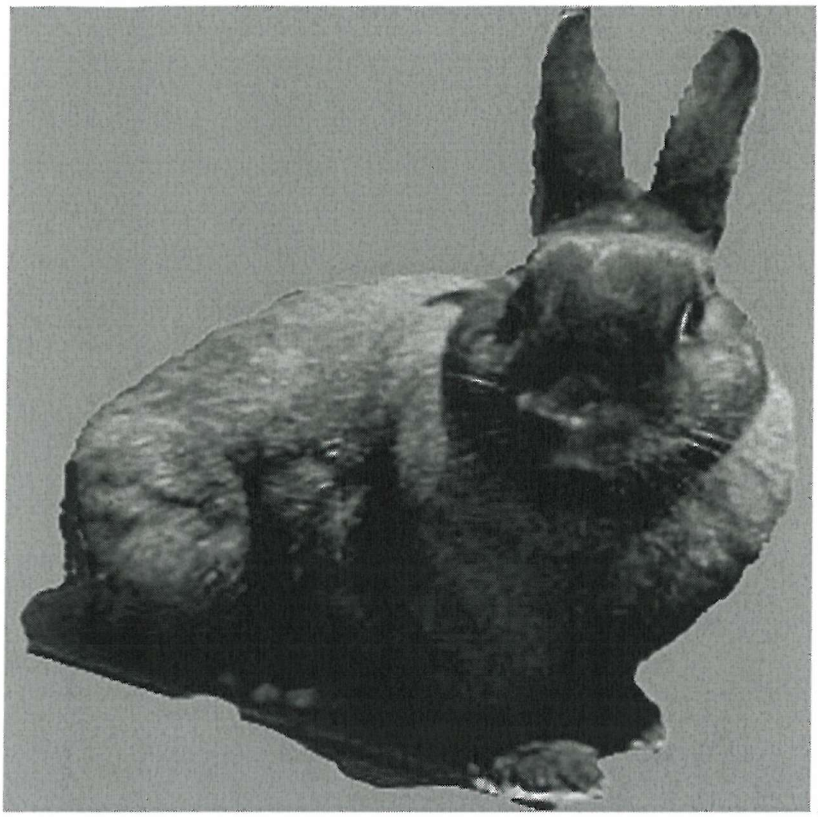
Appendix One: Sample Stimuli from Studies 1, 2, 3 and 5



A proximal spider



A distal spider

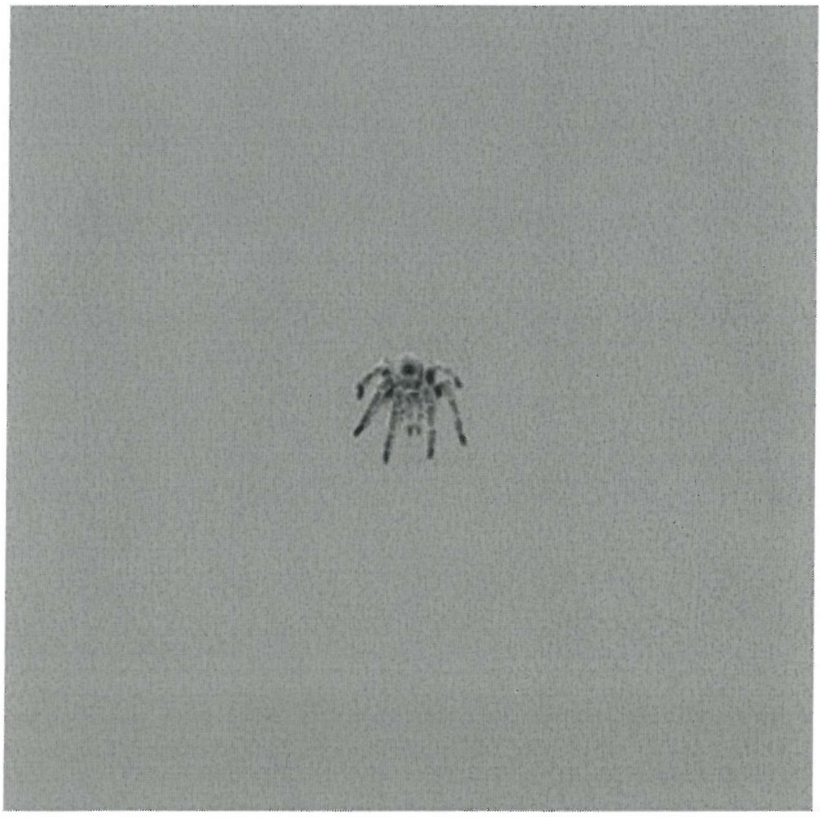


A proximal rabbit

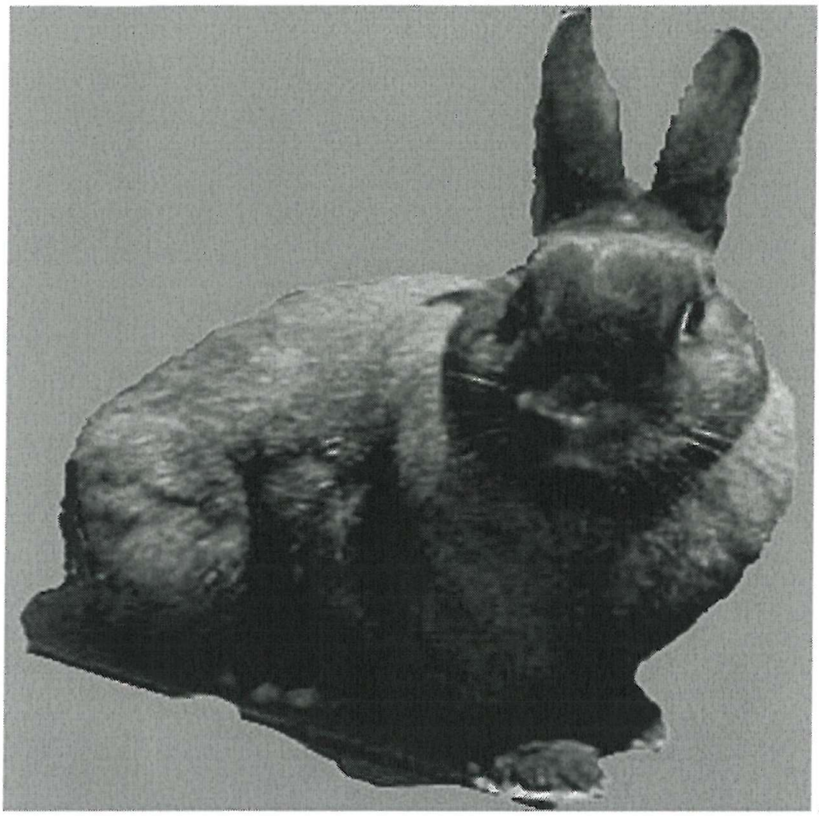
A distal rabbit

Appendix Two: Sample Stimuli from Studies 4 and 6

A proximal spider



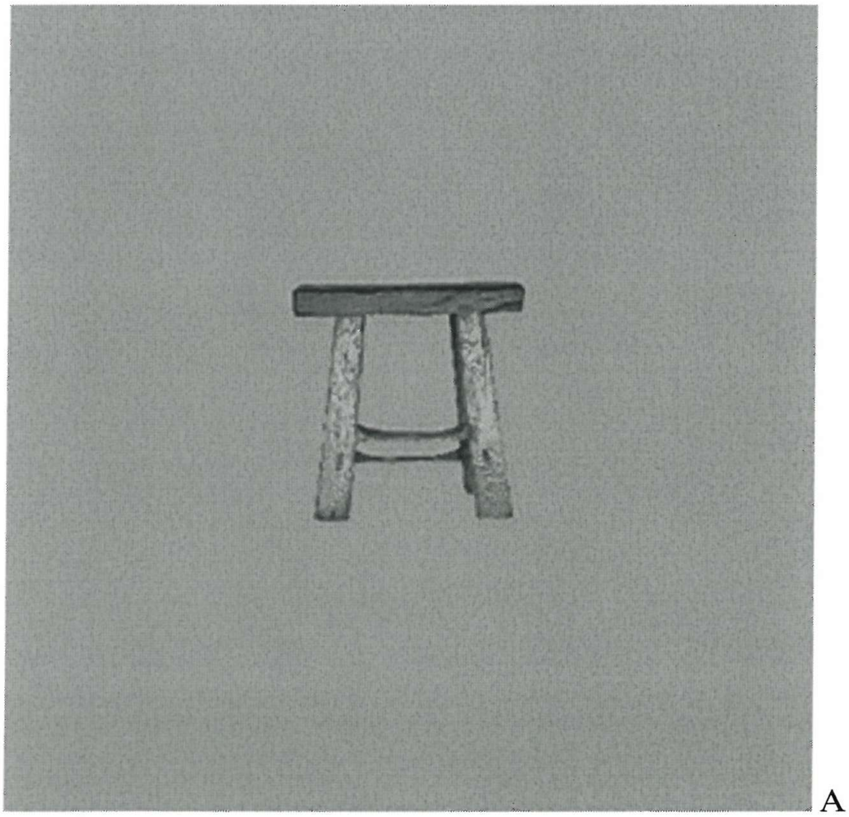
A distal spider


A proximal rabbit


A distal rabbit

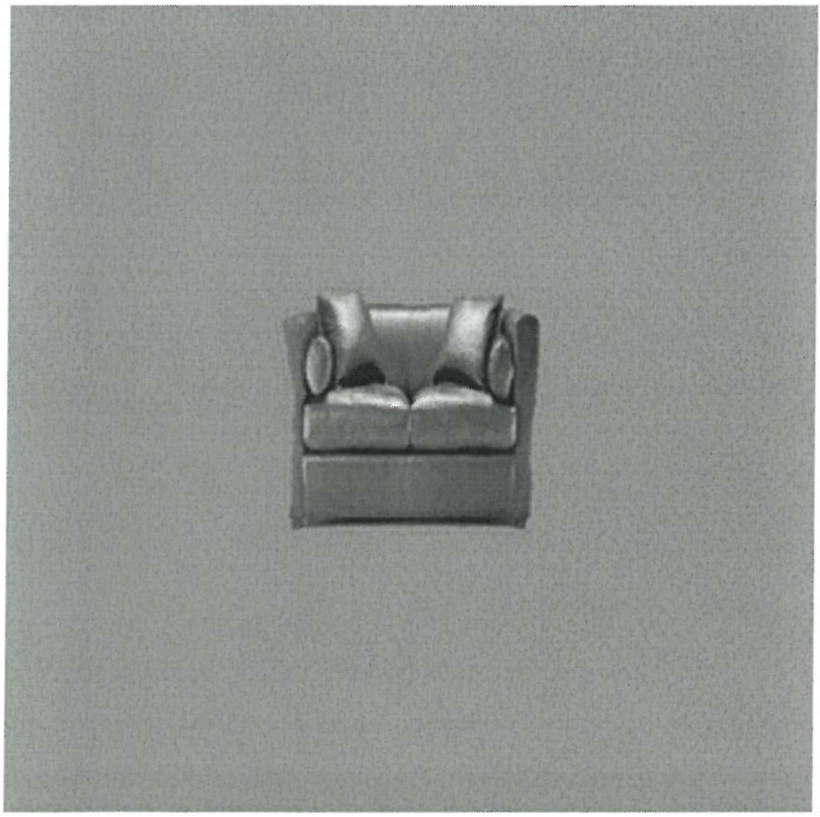
Appendix Three: Sample Furniture Stimuli from Study 5

A proximal stool



A distal stool

A proximal sofa



A distal sofa

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