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University of Sussex

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DPhil

October 2011

**Acquiring Fear and Threat related Attentional
Biases through Informational Learning**

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Summary

Research has found that threat related attentional biases towards novel animals can be induced in children by giving threat information about the animals. Naturally occurring (i.e. non-induced) threat related attentional biases have also been found in both children and adults in the past research. The naturally occurring threat stimuli mainly include phobia stimuli and the threat stimuli that are assumed to have evolutionary roots (e.g., threatening facial expressions, and poisonous animals). In the present research, induced and naturally occurring threat related attentional biases were investigated and contrasted in children and adults. The participants' manual RTs and eye movements were measured in five experiments using the visual search paradigm to examine the attentional biases.

The participating children, regardless of their trait anxiety scores, showed attentional bias toward angry faces as indexed by RT and eye movement measures. In the second and third experiments, children acquired fear of novel animals by listening to threat information about them. They later showed attentional bias to the newly feared stimuli: the presence of the animal's images interfered with detecting an irrelevant target, and the animal's images were detected faster than the control stimuli when presented as hidden targets in naturalistic scenes. In the fourth and fifth experiments, no enhancement of attentional bias towards fear-relevant stimuli due to receiving threat information was evident, as no difference was found between the threat information and the no information snake stimuli in terms of attention deployment measures. Strong evidence of naturally occurring attentional bias toward snake stimuli, however, was found in both RTs and overt attention indices.

Overall, the RT data provided more robust evidence than the eye movement data in support of the predicted threat related attentional biases. It was argued that attentional biases to fear stimuli might have different levels which develop over time, with fast threat processing (indexed by faster RTs) appearing soon after the fear is acquired.

I hereby declare that this thesis has not, and will not be, submitted in whole or in part to another university for the award of any other degree.

Signature:.....

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Overview of thesis

The main question of this thesis is whether fear learning through informational pathway leads to attentional bias. This question is explored for two types of stimuli: novel and fear-relevant stimuli.

The thesis consists of five chapters. The main topics of the literature review chapter (Chapter 1) are the pathways to fear learning, evolutionary fears, and threat related attentional biases.

The first experiment, reported in Chapter 2, explores a typical naturally occurring threat related attentional bias, that is, the attentional bias towards threatening facial expressions. The attentional deployment patterns related to this bias are used as the comparison basis against which the newly acquired biases are compared in the next chapters.

The second and third experiments, reported in Chapter 3, examine the acquisition of attentional biases towards novel stimuli after receiving threat information about the stimuli, and the visual scanpath patterns associated with the induced biases. In the second experiment, the interference caused by the newly feared stimuli when detecting fear-irrelevant targets is measured to examine the induced biases, and in the third experiment, the efficiency of detecting the newly feared stimuli in naturalistic scenes is measured to examine the acquired biases.

In the fourth and fifth experiments, reported in Chapter 4, it is investigated whether receiving threat information about fear-relevant animals can enhance attentional bias towards them. Three different variants of the visual search paradigm are used in the experiments of this chapter to tap the possible enhanced bias effects.

In Chapter 5, the naturally occurring and induced threat-related attentional biases examined in the previous chapters are compared; moreover, the theoretical and clinical implications of the research findings, and the limitations of the current research are discussed, and some suggestions are made for the future research.

Chapter 1: A Review on the Literature of the Origins of Fear and Threat related Attentional Biases

This chapter consists of four sections: general concepts, fear acquisition theories, threat related attentional biases, and conclusion. In the general concepts section, first, anxiety, fear and phobia will be defined, then the research on the prevalence and lifespan developmental trends of these problems will be briefly reviewed. Finally in this section, the issues concerning the evaluation of fear and anxiety and their potential solutions will be discussed.

In section 2, first the classical conditioning theory of fear learning will be introduced, and the main modifications made to the theory to date will be discussed. Next in this section, the evolutionary oriented fear acquisition theories, namely, the preparedness and the non-associative theories will be introduced and evaluated. The Rachman theory of direct and indirect pathways to fear learning and its relevant research will also be reviewed, and finally the contemporary behavioural approach to fear learning will be outlined.

Section 3 begins with a discussion on threat related attentional biases as information processing abnormalities. Then the frequently used paradigms for measuring the biases, that is the emotional Stroop, dot probe, visual cueing, and visual search paradigms, will be introduced and evaluated. Next in this section, the research on the visual search task, which is the paradigm used in the studies of this thesis, will be reviewed in more detail. This review includes attentional biases towards emotional facial expressions, and fear-relevant stimuli. The findings of the eye tracking methodology, which has been used with different attentional bias paradigms, will also be discussed when reviewing the research on the paradigms. Moreover, the methodological issues, and the debates about the attentional biases' mechanisms will be addressed in the discussions of the current chapter.

In the final section of this chapter, a conclusive summary of the discussions of this chapter, in relation to the aims of the present thesis' studies, will be presented.

1.1. General concepts

1.1.1. Anxiety, fear, and phobia

Rachman (1998) defined anxiety as a feeling of unpleasant suspension due to vague anticipation of a threatening event. According to him, fear is also a feeling of unpleasant anticipation and tension, but the two can be distinguished based on their cause, duration and maintenance. In terms of cause, it is not easy for anxious individuals to distinguish the cause of their unpleasant tensions, and in the most extreme cases, pure anxiety is objectless and diffuse. The cause of fear, on the other hand, is identifiable with a specific focus, for example, a poisonous snake. In terms of duration and maintenance, pure anxiety has no certain beginning and termination time points, and seems to be felt by anxious individuals almost all the time. Fears, however, are generally episodic and diminish when the danger is no longer imminent (Rachman, 1998).

The distinction between fear and anxiety in this view relies mainly on the stimuli that cause the feelings: anxiety is often “prestimulus” (i.e., anticipatory to a potentially threatening stimulus) whereas fear is “poststimulus” (i.e., elicited by a definite fear stimulus)(Öhman, 2000). However, Epstein (1972, as cited in Öhman, 2000) argued that external stimuli are not sufficient to distinguish fear and anxiety. In his view, the feeling of fear or anxiety depends on how the organism can respond to the perceived threat. Anxiety appears when the response to threat is blocked. In other words, fear is a motive for coping behaviours such as escape and avoidance, but when coping attempts fail (e.g., if the situation is unavoidable) fear is turned into anxiety. Anxiety therefore can be defined as unresolved fear, or alternatively, as a state of undirected arousal following the perception of threat from the outside world. It is argued by Öhman (2000) that Epstein’s model also implies on a more basic type of anxiety which results from the unconscious input to the conscious perception system. Because the source of this input is not available to consciousness, the resulting state of undirected arousal is experienced as anxiety, or as “undirected alarm”. The person knows something is wrong, but cannot pinpoint any clear reason for it. This type of anxiety therefore depends entirely on the unconscious mechanisms, whereas anxiety resulting from interference with avoidance responses is more readily appraised at the conscious level as originating in the external world or in personal shortcomings. Such definition of anxiety is consistent with the

accepted view in psychotherapy (Rachman, 1998), based on which, anxiety is a vague form of basic fears, and it is attempted to reduce the patient's unclear anxiety to its primary fear roots.

The other theoretical model which discusses the relation of fear and anxiety is the imminence model (Craske, 2003). It is assumed in this model that anxiety/worry and fear are different defensive systems each one of which is activated in response to threats within certain proximity. An undetected and uncertain threat (e.g., the possible occurrence of aversive future events) elicits anxious, worry and alertness, but when the actual threat is detected, fear will be the organism's response. The fear response itself, in this model, has various levels with panic (when the predator strikes) and freezing (at the point of no return) being highest levels of the response. In general, in this model, it is assumed that fear and anxiety responses are qualitatively different, and the responses' characteristics depend on the proximity of threat. It has been argued (Craske, 2003) that fear is non-cognitive and involves in primitive brain mechanisms, whereas anxiety/worry involve in cognition and more developed brain mechanisms. Such a distinction between fear and anxiety signs can also be traced in factor analytic studies of anxiety symptomatology. In these studies two factors have been distinguished: the first one consists of internal autonomic arousal signs, and behavioural fight-flight reactions, and can be identified as fear. The second factor consists of tension, apprehension, and worry, and can best be labelled as anxiety (Muris, 2007; Craske, 2003). These signs can be seen as the two states' adaptive functions: Fear prepares the body to react quickly by activating the sympathetic nervous system (SNS), which in turn increases the heart rate, respiration and muscle tension. Therefore, fear reactions are typically emergency reactions to proximate dangers, whereas, anxiety is a state of increased general vigilance (Muris, 2007; Rachman, 1998).

From a psychophysiological view (e.g., Lang, Bradley, & Cuthbert, 1998; Lang, Davis, & Öhman, 2000), both fear and anxiety reactions are organised by mid-brain, sub-cortex, and primitive cortical brain structures, which are shared structures amongst mammals and are assumed to be results of a common evolutionary history. The research of fear reactions, in a great deal of which animal subjects have been used, has indicated that the amygdala plays an essential role in the somatic and autonomic changes following perception of threats. This small structure receives inputs from many cortical and sub-cortical brain areas including the sensory cortex through the thalamus, and mediates specific signs of fear and anxiety through its projections to the hypothalamus,

the central grey, and brainstem areas. The direct effect of the amygdala in fear expressions has been shown by eliciting the specific fear signs through electrical stimulation of this structure. For example, galvanic skin response, paleness, pupil dilation, and increase of blood pressure are elicited by activation of the lateral hypothalamus, which results from electrical stimulation of central nucleus of the amygdala (Lang, et al., 2000). When the threat is perceived, the activation of the amygdala according to LeDoux (e.g., LeDoux, 2000) can occur quickly in a shortcut route through thalamus and without the involvement of the cortex. In the case of anxiety, threat cues could be more general and with longer durations, and reactions to them could be more directed to a preparation for action than a fast reaction. Another subcortical brain structure, the bed nucleus stris terminalis, which is closely related to the amygdala, and has been considered as an extension to it, might be specifically related to the expressions of anxiety state. Lang, Davis, and Öhman (2000) have concluded from the animal research on the startle reflex that the bed nucleus stris terminalis probably specifically mediates somatic and autonomic anxiety signs. The structure projects to the same target brain areas as the amygdala does, however, it is responsive to more prolonged activations caused by less specific stimuli (which can be considered as the properties of anxiety evoking stimuli) as compared to fear cues.

In addition to fear and anxiety, another term that needs to be defined in this section is phobia. This term is closely related to fear, because both result from a specific and imminent source of threat in the environment. However, a distinction between the two can be made based on the accuracy of the danger source identification and evaluation. A reaction to danger is called phobic when the perceived source of danger is wrongly identified (i.e., the object or situation is not a real threat), or when the danger is identified correctly but the reaction to it is out of proportion (Rachman, 1998).

Although in Rachman's definition a clear distinction between fear (as a rational and proportionate reaction to danger), and phobia is identifiable, such a distinction is less certain in the definitions used by other researchers in this field. As stated by Muris (2007) most current researchers and clinicians use fear to refer to "phobic disorders that are all characterised by a negative emotional response in relation to a certain stimulus or situation that is out of proportion to its actual danger" (pp. 2 and 3). Thus in this view, fear is defined as a similar reaction to phobia without an effort to differentiate the two terms.

In this thesis, we will follow the same definition of fear that, as mentioned above, is referred to by most researchers and clinicians, that is, the phobic-like, intense, and disproportionate reaction to specific sources of threat. Therefore, for instance, the term “fearful individuals” is used for the individuals with intense and out of proportion fear. On the other hand, wherever the term “phobic individuals” is used, it means that the individuals have been diagnosed as phobic patients by means of psychological tests. Moreover, in accordance with most researchers and clinicians, by using the term anxiety, we will refer to “the anxiety states that are characterised by tension, apprehension, worry and general distress which emerge without being exposed to any specific source of danger” (Muris, 2007, p 3).

1.1.2. Measuring fear and anxiety

In Lang's model (e.g., Lang, Levin, Miller, & Kozak, 1983), fear consists of three separate components or response systems. The response systems include the subjective feeling of being frightened, which can be assessed by self-reports; physiological changes associated with the feeling; and the efforts to avoid the frightening situation or flee from the situation, which is observable at the behavioural level. Consistent with this model, Rachman (1998) emphasised on the distinction between the three components, and pointed out that in some situations the fear responses do not co-vary. For instance, sometimes people who are chronically fearful of a situation, experience subjective fear when they face the situation, but neither they show one of the physiological manifestations of fear such as sweating and trembling (which are more salient in acute fears as compared to chronic ones), nor try to flee from or avoid the situation. Rachman argued that such a lack of co-variation can cause problems in experimental settings: some potential participants report a high fear of, say, snakes in a screening session, but in the real experimental session when they encounter the feared stimulus, they display little or no sign of fear. A participant with a high self-reported snake fear may even hold a snake without hesitation. Rachman suggested that for assessing fear and anxiety one should not merely rely on one of the three response components; and an evaluation will be most precise and reliable by measuring all the components.

Zinbarg (1998) has argued that although Lang's and Rachman's approaches can account for physiological arousal, and avoidance-escape behaviour, it is unable to explain attentional and interpretational biases that play an important role in the

aetiology and maintenance of the disorders. Zinbarg suggested a hierarchical model in which a construct of fear serves as a higher order latent factor, and the three response systems (i.e., the three response systems in Lang's model which consist of the subjective feeling of fear, physiological signs of fear, and behavioural avoidance of the feared stimulus) are the more basic factors that are integrated and coordinated by the higher order factor. In this model, it is this latent factor that coordinates processing of threat related information and behavioural responses to threats. Therefore, the processing prioritisation of threatening over non-threatening stimuli, and consequently faster reactions to the threatening stimuli are both mediated by the proposed latent higher order factor.

1.1.3. Normative fears and prevalence of anxiety disorders

Both interviews and paper-based questionnaires have been used to investigate the normative fears in adult and child populations. Using interview, fear of animals have been found to be one of the most common fears among adults (e.g., Agras, Sylvester, & Oliveau, 1969; Costello, 1982) and children (e.g., Muris, Merckelbach, & Collaris, 1997). In Costello's study, after fear of animals, fear of heights, tunnels and enclosed spaces, and then social fears, fear of injury, and fear of separation were the most common fears in adults. In Muris, Merckelbach and Collaris's study, after fear of spiders, fears of being kidnapped, predators, the dark, frightening movies, snakes, being hit by a car, being teased, parent dying, and burglar breaking into the house were the most common fears in children.

In paper-based scales, animal fears rank lower among the most common fears in both adult and child populations. In adults, for instance, Arrindell, Cox, Van der Ende, and Kwee (1995) employed the Fear Survey Schedule (Wolpe & Lang, 1964), and consistent with other studies using this frequently used scale, found that social fears, fears of injury or illness, agoraphobic fears, fears of sexual and aggressive scenes and finally fear of harmless animals were the most common fears. Similarly, Muris (2007) concluded that in several studies that have used the Fear Survey Schedule for Children-Revised scale (FSSC-R, Ollendick, 1983) in non-clinical child populations, the most common fears were not being able to breathe, being hit by a car or truck, bombing attacks/being invaded, getting burned by fire, falling from a high place, burglar breaking into the house, earthquake, death/dead people, illness, and at last snakes.

After a review on the childhood fear studies, Muris and Field (*in press*; see also Muris, 2007, for another review) concluded that regardless of the methodology used for data collection, the range of fear signs displayed by children seems similar to the ones seen in adults. These include animal phobia, height phobia, claustrophobia, and blood-injection-illness phobia, and according to Muris and Field, children seem to have a realistic sense to perceive global threats, by which, they seem to mean that children, likewise adults, are able to recognise the common threats that are dangerous for all human beings.

Anxiety disorders are the most prevalent form of mental disorders (Oltmanns & Emery, 1998). The estimates of the prevalence rates of anxiety disorders in life time range between 8.3% and 27% (Costello, Egger, & Angold, 2004; cited in Muris, 2007). Amongst adults, specific phobias and social phobia are the most common anxiety disorders with between 9% and 12% lifetime prevalence rates, and PTSD, OCD, GAD, and agoraphobia-panic are the next prevalent disorders with between 1% and 7% lifetime prevalence rates, with the rates varying in different studies (Butcher, Mineka, & Hooley, 2010; Oltmanns & Emery, 1998; Davey, 2008; Brown & Lawrence, 2009; Taylor, Cox, & Asmundson, 2009; McNally, 2009). In children, prevalence rates of between 7% and 10% for specific phobias, between 2% and 5% for separation anxiety disorder, between 1% and 11% for GAD, and between 1% and 4% for OCD have been reported in different studies (Gelder, Harrison, & Cowen, 2006; Davey, 2008). In two factor analytic studies, symptoms consistent with the DSM categorization of childhood anxiety disorders were investigated in two different childhood age ranges. In children between 2 and 6 years old, separation anxiety and social anxiety symptom clusters were most prevalent (Spence, Rapee, McDonald, & Ingram, 2001), and in children between 8 and 12 years old, the most prevalent symptom clusters were social phobia, OCD and GAD, respectively, whereas agoraphobia-panic symptoms had the lowest prevalence (Spence, 1997). The findings with regard to the prevalence of fear and anxiety symptoms in childhood have led some researchers (e.g., Muris, 2007; Gullone, 2000) to conclude that fear and anxiety are part of a normal childhood development trend.

Although childhood anxiety problems in most cases are short-lived; in a substantial number of children the symptoms last long enough so that the child can be diagnosed as an anxiety disorder sufferer. The potential consequences that childhood anxiety disorders have on the sufferers' future make these disorders more critical. These problems at this level, or even in non-clinical levels, are often seriously disturbing and

can significantly interfere with children's daily activities and social functioning (e.g., Ollendick & King, 1994; Strauss, Frame, & Forehand, 1987). Research has also shown that the occurrence of anxiety disorders in childhood, significantly predicts the disorders' recurrence later in life (e.g., Gullone & King, 1997; Spence & McCathie, 1993). These findings indicate the importance of early treatment of anxiety symptoms to minimise their adverse impact on people's future.

1.1.4. The developmental course of fear and anxiety

Normal fear and anxiety follow a predictable course. For example, Bauer (1976) in a study on children aged 4 to 12 years found that fear of ghosts and monsters are most prevalent when children are younger, but these fears become less frequent in 10 to 12 year-old children. On the other hand, the prevalence of fear of physical harm is higher in older children than children aged 4 to 6 years. In line with these results, Muris, Merckelbach, Gadet, and Moulaert (2000) found that fears and scary dreams related to imaginary creatures were less frequent in older children, but the frequency of worry about school performance constantly increased as children grew older, and became notably more common in 7- to 12- year-old children than in their younger counterparts.

Although the frequencies of the majority of fears, such as fears of the dark and animals will reach their peak during adolescence and will decline in the following years; for other fears, such as fear of illness and injury, the highest frequency occurs in the age of middle adulthood (Muris, 2007). Increased fears of heights and water has also been found to be more common among the elderly (Kirkpatrick, 1984).

A similar developmental pattern is found for childhood anxiety disorders. For instance, separation anxiety is prevalent in children up to 9 years old, but becomes less common as children grow older. On the other hand, GAD and social phobia, are less frequent in younger children, but become more common in adolescents (Weems and Costa, 2005, as cited in Muris, 2007). This trend is in accordance with the increase in fear of evaluation and the decrease in fear of punishment among adolescents and as children grow older (Westenberg, Drewes, Goedhart, Siebelink, & Treffers, 2004; for a review, see also Muris & field, *in press*)

Muris and Field (*in press*) proposed two possible explanations for the developmental trend in fears and anxiety. These include evolutionary basis, and cognitive capacities. From an evolutionary perspective, the things that are potentially

dangerous for humans are different in different ages, and the threat objects vary over the course of development. Infants are defenceless, and for survival, they need to be afraid of a wide range of threats, whereas for toddlers who are capable of moving around but are not strong enough to defend themselves against predators and poisonous animals, these threats become the main concerns. Physical strength gives adolescents the capability of defending themselves against physical threats, and now being socially accepted becomes their main concern, therefore their dominant fear converts to social evaluation fears. The trend of decline in physical abilities and health makes illness and injury the more prevalent fears in the later stages of life.

Muris and Field's other explanation was that the trend follows the changes in cognitive abilities throughout the lifespan. They argued that to feel fear or anxiety, one must perceive and conceptualise the threats that cause fear and anxiety, and the conceptualisation depends on cognitive abilities in different stages of development. In early infancy immediate and concrete threats such as loud noises and loss of physical support seem to be perceived as the main threats. In Muris and Field's model, fear of strangers and separation anxiety is associated with the development of the ability to recognise familiar faces, and infants show fear of strangers when they start to recognise familiar faces. In toddlers, the emergence of fear of imaginary creatures are assumed to be closely linked to their magical thinking (Bauer, 1976), and the emergence of fear of animals is linked to children's ability to move around independently and their awareness of the external world and its potential dangers. According to Muris and Field, after age 7, children's increasing ability of inferring cause-effect relationship enables them to increasingly anticipate potential negative consequences followed by different acts. Such an increase in the anticipation and inference capacities are assumed to be linked to the increase in worry (which is threat anticipation) and the extended range of fear-causing stimuli.

Muris and Field argued that the evolutionary explanation for the developmental trend of fears is difficult to verify empirically, but there is evidence that supports the cognitive capacities explanation. For instance, in Muris, Merckelbach, Meesters, and van den Brand's (2002) study, children's cognitive maturation, measured by a number of Piaget's conservation tasks, was associated with their ability to catastrophise potential outcomes of events, which is a cognitive process underlying worry. Moreover, the effect of age on children's fear of social evaluation could be fully explained by their

socio-cognitive maturity in Westenberg et al.'s (2004) study. These studies, according to Muris and Field, suggest that fear and anxiety are mediated by cognitive development.

1.2. Theories of fear acquisition

1.2.1. Classical conditioning

Watson and Rayner's (1920, as cited in Field, 2006b; and Mineka, 1985) experiment was the first attempt to explain phobia acquisition based on conditioning processes. In this experiment, fear of a non-feared stimulus was induced to an infant, Little Albert, by associating the stimulus with a fearful stimulus seven times. In the beginning of this experiment, Little Albert did not show any sign of fear towards the non-feared stimulus, a white rat. However, after the rat was repeatedly shown to him in the learning trials along with the fearful stimulus, the sound of a hammer striking a steel bar, the infant displayed fear reactions to the initially non-feared stimulus. Moreover, Albert's fear reactions were generalised to the stimuli which were similar to the rat, such as Watson's hair and a Santa Claus mask.

This experiment showed that fear response can be conditioned to previously neutral stimuli through association with traumatic or painful experiences, and once the phobic fear is learnt, it would generalise to other similar objects or situations. These findings are the initial core of the classical conditioning account of fear acquisition. In this account's terms, the naturally feared stimulus is an unconditional stimulus (US), and the stimulus for which the fear is acquired is a conditioned stimulus (CS).

In the behavioural attempts to explain phobic disorders (e.g., Wolpe & Rachman, 1960) phobias originate from conditioning experiences that have occurred at some time in the past. The major features of the classical conditioning account are (Rachman, 1998):

- Non-feared, neutral stimuli that are paired with a frightening or painful state acquire fearful properties.
- The strength of the association and its resulted fear depend on the number of times that the noxious experience and the previously neutral stimulus are associated, and also on how intense is the fear or pain that has been inflicted by the noxious stimulus.

- Repetitive association between US and CS increases the probability of fear acquisition; moreover, fear development is more likely when people are exposed to a high intensity pain or fear, or when they are confined. When a very intense traumatic event is paired with the neutral stimulus, the effect can be so strong that a conditioned fear may be acquired in only one conditioning occasion, and such a conditioned fear may last long and resist extinction.
- Fearful qualities generalise to the stimuli that resemble the feared ones, and consequently these similar stimuli, which can be called as secondary CSs, also develop fearful qualities.

Conditioning theory of fear acquisition is well supported by numerous studies. It has been shown that naturally occurring traumatic events can lead to the acquisition of phobias even after experiencing a single traumatic event. For instance, lightning storm survivors showed significantly higher fear of thunderstorm and lightning than the control group (Dollinger, O'Donnell, & Staley, 1984), and the survivors of a sunken cruise ship showed intense fears of water, water travel, and ships, and their fear of water travel had also been generalised to other means of travel (Yule, Udwin, & Murdoch, 1990). In other studies that investigated the origins of phobias by retrospective self-reports, a vast proportion of individuals attributed the origin of their phobias to a direct conditioning event for many types of phobias, such as dental phobia (Davey, 1989; Öst & Hugdahl, 1985), blood-injury and injection phobias (e.g., Öst, 1991; Kleinknecht, 1994), and dog phobia (e.g., Di Nardo, Guzy, Jenkins, Bak, & et al., 1988).

In addition to these real life studies, several laboratory experiments have also shown that fear reactions can be acquired through conditioning. For instance, it was shown in Neumann, Waters, Westbury, and Henry (2008) and Waters, Henry, and Neumann's (2009) studies with child participants that skin conductance response, as an aversive fear reaction, to geometric shapes (CSs) was enhanced after the stimuli were presented along with loud tones (US) in a single conditioning session with a small number of trials. Waters et al.'s study also found that the fear acquisition effect was higher for anxious children. In another study (Campbell, Sanderson, & Lavery, 1964) fear was acquired in a single trial which involved a severe aversive experience. In this study a neutral tone was paired with an injection of scoline, which induces a transient respiratory paralysis. A strong conditioned fear response was established in the single trial, which not only was not extinguished, but also became stronger in 100 extinction trials.

As the final evidence for plausibility of the conditioning account, effectiveness of exposure-based therapies in treating phobias can be mentioned. Several studies have shown the effectiveness of the method in treating specific phobias (see Davis & Ollendick, 2005 for a review). As an instance, Öst, Svenson, Hellström, and Lindwall (2001) found that specific phobias (which included animal phobias and miscellaneous specific phobias such as phobias of injection, blood, thunderstorm, and even mummies and yogurt) were improved by a single session exposure therapy. The fact that exposure-based treatments are effective in treating specific phobias lends some support to the contention that phobias are learned through conditioning mechanism. Based on this argument, when the phobia is learned through the association of neutral and aversive stimuli, breaking the link between the stimuli can neutralise the learned response and cure the morbid fear.

Since the initial conditioning theory of fear learning was suggested, various observations and research findings have added to our understanding about fear learning processes. These observations and findings have been the basis of complementary accounts and modifications to the classical conditioning model. In the following, first the modifications that are most relevant to this thesis will be reviewed. This mainly include the role of biological significance of fear stimuli (evolutionary preparedness) in fear learning, cognitive mediators of fear learning, and indirect fear pathways. Finally, at the end of this section, some contemporary fear learning models (i.e., Davey, 1997; Mineka & Zinbarg, 2006; Field & Purkis, *in press*), which incorporate the modifications, and present an advanced account of fear learning will be briefly discussed.

1.2.2. Evolutionary oriented fear acquisition theories

1.2.2.1. Evolutionary fear predisposition

The assumption of equal conditionability, or equipotentiality, in the classical conditioning theory states that all stimuli in the environment have an equal chance to be transformed into fear-eliciting stimuli, providing that they are exposed for roughly the same number of times (Rachman, 1998). However, in real world the distribution of fears seems far from being random, as fears of some stimuli and situations are extremely common and fears of other stimuli are very rare.

The common fears appear to occur for limited sets of stimuli. For instance, “fears of interpersonal events or situations,” “fears of death, injuries, illness, blood, and surgical procedures,” “fears of animals,” and finally “agoraphobic fears” were the most common fears in Arrindell, Pickersgill, Merckelbach, Ardon, et al.’s (1991) study in which the results of several factor analysis studies using self-reported fear questionnaires were collated. Phobias distribution is also similar to the distribution of fears. For instance, the last three factors found by Arrindell et al. are very similar to the four categories of specific phobias in DSM-IV-TR (American Psychiatric Association & American Psychiatric Association Task Force on DSM-IV, 2000) which are “blood, injuries, injection,” “situational fears (e.g., enclosed spaces),” “animals,” and “the natural environment (e.g., height, water).”

In general, stimuli and situations such as animals (especially snakes and spiders), height, water, enclosed spaces, blood, injury, injection, death, and illness appear to be the common phobic stimuli (Merckelbach & de Jong, 1997; Davey, 2008). Some of these stimuli (such as little spiders) are indeed harmless, and the people who fear the stimuli usually know this. On the other hand, people rarely acquire phobias of stimuli such as knives, guns, electric plugs, hammers, and traffic. This is despite the fact that these modern era threat stimuli are encountered frequently in everyday life, and are more likely to be associated with pain and trauma than the prevalent phobias’ stimuli (Rachman, 1998; Bennett, 2006).

It has been attempted to explain the counter-intuitive pattern of distribution of the common fears based on evolutionary accounts. According to these accounts, the common feared stimuli and situations were life threatening for primates and humans during the course of evolution. This has led them to be genetically predisposed to acquire fear of these stimuli (e.g., Öhman & Mineka, 2001; Seligman, 1971; Mineka & Öhman, 2002a), or to possess inborn fears of the stimuli (e.g., Poulton & Menzies, 2002).

The main categories of the assumed innate sources of fears for humans and other mammals from evolutionary perspective can be considered as: 1) predatory fears, that is, predators and the stimuli that signal their presence for prey species; 2) physical environmental dangers, such as water and height for terrestrial species; 3) fears originating from conspecific threats, such as fear of strangers; 4) situations associated with increased risk of predation and other dangers, such as unfamiliar objects and situations, being alone for social species, being in an open field for the prey species that

rely on cover for hiding from predators, darkness for diurnal species and illumination for nocturnal ones (Russell, 1979).

Mainly two fear learning accounts have considered evolutionary roots for fears: the preparedness account which contends a predisposition to acquire fear of evolutionary threats, and the non-associative account which proposes inborn fear of the evolutionary threats. These two accounts are briefly outlined in the following.

1.2.2.2. The preparedness fear acquisition theory

In the preparedness theory (Seligman, 1970, 1971), the concept of equipotentiality was replaced by evolutionary predisposition. Thus, in this theory, the likelihood of learning fear of different stimuli is not considered as equal, and fear of the evolutionary predisposed stimuli is highly prepared to be learned.

The prepared association was originally introduced by Seligman (e.g., Seligman, 1971) to explain the findings of some conditioning studies which had shown that different CSs have different potentiation of being paired with certain USs. As an example, he mentioned the taste aversion studies (e.g., Wilcoxon, Dragoin, & Kral, 1971) which had shown that rats can readily learn to associate tastes, but not external cues such as lights, with nausea. He argued that such associations which are learned in a single trial, or in very few trials, are prepared associations, as compared to unprepared or contraprepared associations that take numerous trials to be learned (or not learned). The preparedness concept was then extended to fear learning mechanism to explain why phobias do not occur for arbitrary groups of stimuli which are associated with trauma, but to a rather limited set of stimuli (Mineka & Öhman, 2002b). In Seligman's (1971) view, as a result of evolution, we inherit tendencies to learn fear of the evolutionary threat stimuli.

It should be emphasised that Seligman did not suggest that prepared fears are inborn or innate fears, rather they are predispositions that facilitate learning fears of the selected stimuli through conditioning (Davey, 2008). In other words, in this theory (unlike non-associative fear learning theory which will be explained in the following), fear of fear-relevant stimuli is needed to be learned through conditioning, and these stimuli do not elicit fear before their fear is learned. Therefore, they are not considered as inborn unconditioned fear stimuli, and instead, the tendencies to learn fear of these stimuli are inherited in this model. The mechanism of inheriting the prepared fear tendencies is evolutionary selection pressures. That is, the likelihood of survival of our

ancestors who acquired such tendencies would have been higher than the ones who approached the dangerous situations recklessly. Consequently the survived ancestors contributed to the development of a predisposition of evolutionary fears and passed it on to the next generations.

Similar to this argument, Mineka and Öhman's model (e.g., Mineka & Öhman, 2002b; Öhman & Mineka, 2001), which is an elaboration of Seligman's preparedness theory, proposed a biological fear module in humans' (similar to mammals') nervous system that is responsible for selectively processing evolutionary fear inputs. In line with this proposal, they concluded from several studies (e.g., in a review by Öhman, 2005) that a subcortical brain structure centred on the amygdala is involved in detecting and processing threat-related stimuli. Following threat detection, the structure provides timely responses to the threats. The main fear systems in this module are the predator-defence system, which responds to feared animals and the stimuli accompanied by their heightened risk, and the social-submissiveness system, which responds to the threats originating from conspecifics (such as threatening facial expressions, and stimuli which signal dangerous social interactions). Hereafter, "fear-relevant," a term employed by Öhman and his colleagues (e.g., Öhman & Mineka, 2001) to minimise the dependence of the construct on evolutionary theoretical presumptions, will be used instead of "prepared fear."

Providing a reasonable explanation for the non-random distribution of fears, which according to Merckelbach and de Jong (1997) is the dominant explanation for this debate, is an important strength of the preparedness theory. The theory has also received considerable support from fear learning studies. The results of some of these studies are reviewed in the following.

Conditioning studies have found stronger fear learning effects for fear-relevant than fear-irrelevant stimuli. In these studies, phylogenetic fear-relevant stimuli (snake and spider images), fear-irrelevant stimuli (human faces and houses), and ontogenetic fear-relevant stimuli (electrical outlets and guns) were paired with electrical shocks as US, while skin conductance response (SCR) was recorded as CR. The conditioned fear responses were acquired more readily (e.g., in fewer trials), and were more resistant to extinction for the phylogenetic fear-relevant stimuli, as compared to the fear-irrelevant and ontogenetic fear-relevant stimuli (e.g., Hugdahl & Kärker, 1981; Cook, Hodes, & Lang, 1986; Öhman, Erixon, & Lofberg, 1975b).

Observational learning studies using primate subjects also show that fear of fear-relevant stimuli is acquired more readily than non fear-relevant stimuli. For instance, in two studies by Cook and Mineka rhesus monkeys observed other monkeys alleged reactions to fear-relevant and fear-irrelevant stimuli displayed on spliced videotapes. In these studies, the fear-relevant stimuli included toy snakes, toy crocodiles, and real snakes, and the non fear-relevant stimuli included toy rabbits, flowers, and wooden blocks (Cook & Mineka, 1989; 1990, Experiments 1 and 2). Only the monkeys who were exposed to the tapes showing the fearful reactions to the fear-relevant stimuli acquired fear. These results are especially important because the observer monkeys were laboratory-reared and did not have any prior experience with the CSs before the experiment and did not initially display any sign of fear to the fear-relevant stimuli. It is worth mentioning that according to the past research (e.g., Cook, Mineka, Wolkenstein, & Laitsch, 1985; Mineka, Davidson, Cook, & Keir, 1984) laboratory-reared monkeys, unlike the wild-reared ones, do not show fear of snakes before learning the fear, which suggests that fear of snakes might not be innate in monkeys.

Finally, there are research findings that suggest the involvement of subcortical and subconscious processes in learning the fear of fear-relevant stimuli. As an instance of the research findings that lends some support to Seligman's proposal, fear acquired for fear-relevant stimuli through conditioning procedures, unlike fear of fear-irrelevant stimuli, is not affected by verbal instructions (e.g., Öhman, Erixon, & Lofberg, 1975a; Soares & Öhman, 1993). In these studies, after instructing the participants that no more shocks will be associated with CSs, the CR (skin conductance response) upon the exposure to fear-irrelevant stimuli started extinguishing, but the CR to the fear-relevant stimuli continued to be high despite receiving the instruction.

As another example, the results of other studies by Öhman and Soares (e.g., Öhman & Soares, 1993, 1994) suggested that responding to evolutionary feared stimuli's pictures (snakes and spiders), but not neutral pictures, can occur without conscious awareness. In Öhman and Soares (1994), the participants were snake and spider phobics, and in the other study, participants were recruited from the general population, but had already been conditioned to snakes and spiders pictures by electrical shocks. The fear-relevant and neutral images were displayed for a very short time (30ms) before being masked: a method used to ensure that the stimuli are not perceived consciously. In both studies the participants' SCRs were increased significantly after seeing the masked fear-related animals' pictures, as compared to the masked neutral

pictures. Also the enhancement of skin conductance was selective for the participants' specific fear object (e.g., for the snake fearful participants it occurred only in response to the snake masked images).

Based on these findings, Seligman (1971, 1970) proposed that learning fear of fear-relevant stimuli (in his own term prepared associations) is probably noncognitive. In his view, the prepared association are irrational and are not cognitively mediated: "unprepared contingencies are learned and extinguish cognitively, i.e., by cognitive mechanisms such as expectations, intentions, beliefs, or attention, while prepared associations are learned more primitively or noncognitively" (Seligman, 1971, pp. 315, 316). Although Seligman did not clearly define the term noncognitive, it can be concluded from his papers (Seligman, 1971, 1970) that by cognitive mechanisms, he referred to higher order and conscious cognitive functions such as reasoning, which are involved, for instance, in the extinction of fear responses to fear-irrelevant stimuli after receiving verbal instructions. By using the term noncognitive, on the other hand, he addressed the subcortical and subconscious processes that are involved in situations such as subliminal attention to phobic stimuli.

In sum, three lines of findings are supportive of the preparedness theory:

- The non-random distribution of fears and phobias which show that most fear and phobia stimuli are phylogenetically fear-relevant,
- The ease of learning fear of fear-relevant stimuli,
- The differences in responding to fear-relevant and non fear-relevant stimuli that imply on the involvement of subliminal cognitive processes when responding to fear-relevant stimuli.

1.2.2.3. Non-associative learning theory

This theory emphasises more than the preparedness theory on the evolutionary roots of selected fears, and proposes that fears such as fear of height, fear of water, fear of the dark, fear of strangers, fear of some animals such as spiders and snakes, and separation anxiety are innate and inborn, and are activated after the first exposure with these stimuli and situations (Poulton & Menzies, 2002). According to this theory, most members of the species who have experienced a normal maturational process will show fear responses to this set of stimuli from their first encounter with them. However, the fearful reactions will normally disappear in the ones who repeatedly encounter the

stimuli without facing aversive and traumatic consequences (habituation effect). In the others who do not have the chance to encounter the stimuli safely, and/or have difficulty in learning not to fear, the fear will not diminish. These poor habituators are the ones who develop phobias and seek therapeutic intervention later (e.g., Poulton, Waldie, Menzies, Craske, & Silva, 2001). The non-associative learning theorists claim that the mechanism through which phobias of the innate evolutionary fear stimuli are acquired is entirely different from the phobias with non-evolutionary themes, such as dental phobia which have been encountered only recently in human's life. While the mechanism of acquisition of the technology era fears is direct conditioning and indirect fear pathways (see the next part of this section for an explanation on the indirect pathways), the underlying mechanism of evolutionary-related phobias is poor habituation. Thus, these theorists have suggested (e.g., Poulton, Waldie, et al., 2001) adding a fourth fear pathway, the non-associative pathway, to the pathways proposed by Rachman (1977).

The non-associative fear learning account has taken as evidence the findings of some studies in which the associative learning was not apparent as the origin of fears and phobias. In some of these studies fearful individuals could not recall fear onset. Such uncertain fear onset has especially been found for some animal phobias such as snake phobia and spider phobia (Davey, 1992; Murray & Foote, 1979). In some other studies, the participants' fears were reported to be always present in spider (Merckelbach, Muris, Nijman, & deJong, 1996), height (Menzies & Clarke, 1993b), and water (Menzies & Clarke, 1993a; Graham & Gaffan, 1997) phobics. This uncertain onset of fears has been taken as evidence for the non-associative account (e.g., Menzies & Clarke, 1995; Poulton & Menzies, 2002). Moreover, Poulton and Menzies argued that the results of prospective studies also support their theory. They reviewed three longitudinal studies on height phobia (Poulton, Davies, Menzies, Langley, & Silva, 1998), water phobia (Poulton, Menzies, Craske, Langley, & Silva, 1999), and separation anxiety (Poulton, Milne, Craske, & Menzies, 2001). These studies used the data collected from a large cohort over an eighteen-year period since the participants' birth. They found, for instance, that height and water phobic individuals had significantly less traumatic experience related to fall and water than the non-phobics. Based on such findings, they concluded that an aversive traumatic experience is not necessary to acquire phobias such as height and water phobia, and questioned the validity of conditioning account in explaining this type of phobias (Poulton & Menzies, 2002).

1.2.2.4. Evaluation of evolutionary (preparedness and non-associative) theories of fear acquisition

Mineka and her colleagues (e.g., Mineka & Zinbarg, 2006; Mineka & Öhman, 2002b) have endorsed the role of biological predisposition in fear learning that was proposed by the preparedness theory. According to them, there is obvious evidence that fear learning in human is shaped by evolutionary contingencies (Mineka & Öhman, 2002b).

Other researchers (e.g., Davey, 1997; Davey, 2008; Field & Purkis, *in press*) are more cautious and critical in their evaluations of the preparedness theory's contentions. Davey, for instance, agrees with the possibility that some fears may be biologically predisposed, but he warns about over-simplification of the matter. He argues that although the theory's claims are interesting and seem reasonable, they are very difficult to verify. As McNally (1995, cited in Davey, 2008) pointed out making up an evolutionary scenario is possible for the fear of almost any stimulus or situation, but verifying the explanation empirically is difficult.

In a recent critical evaluation of the preparedness theory, Field and Purkis (*in press*) questioned the plausibility of the theory's contention that the evolutionary preparedness is the basis of the ease of learning fear for the so-called fear-relevant stimuli. The evidence based on which they made their argument originates from two sets of findings. Firstly, it was found in Hugdahl & Johnsen's (1989) study that ontogenetic fear-relevant stimuli, such as pointed guns, similar to the evolutionary threat relevant stimuli such as snake, were more effective CSs than control stimuli in eliciting fear response (i.e., elevated skin conductance), therefore, the fear response effect is not unique to the presumed evolutionary fear stimuli. Secondly, the results of several studies on indirect fear pathways, which will be reviewed later in this chapter, have shown that fear of fear-irrelevant stimuli can also be readily learned through prospective paradigms, and feared stimuli do not necessarily need to be evolutionary fear-relevant. On the basis of these findings, Field and Purkis argued that although there is evidence to suggest that the nature of the CS plays a role in how easy fear can be conditioned, the preparedness for learning fear of some stimuli is related to individual learning history, rather than the hypothesised evolved predispositions.

Although Mineka and Davey agree, to certain extents, with the preparedness theory; both researchers (e.g., Mineka & Öhman, 2002a; Davey, 2002) are highly critical to the non-associative fear learning account.

Mineka and Öhman (2002a) criticized the non-associative model of fear learning for its reliance on the participants' memory of their phobias onset in retrospective studies, as it is prone to forgetting and distortions. They also believe that the non-associative account refers to the outdated classical conditioning theory. According to them, the contemporary fear learning model takes into account several factors that have major impact on the outcome of the conditioning episode and can explain why not all people who experience aversive conditioning events do not develop phobia (an outline of this model will be presented at the end of this part of the literature review). Based on the current model, for instance, non-phobic individuals recall more traumatic experience with water because they might have been immunized to experiencing water activities by observing others' safe involvements with the activities. Therefore, these individuals get involved more in such activities and are more prone to traumatic experiences, yet are immunized to developing water phobia.

Davey (2002), similar to Mineka and Öhman, criticized the non-associative model for not considering the developments of the contemporary conditioning account of phobias acquisition. In this model, for instance, US revaluation can explain the acquisition of situational phobias (e.g., height phobia and claustrophobia) and animal phobias in the absence of direct conditioning adherence. According to Davey, the US revaluation process that can explain the acquisition of the situational phobias through an associative mechanism is the catastrophic misinterpretation of bodily sensations. In the development of animal phobias, a gradual increase in general disgust sensitivity can be the involved US revaluation process. In Davey's view, it is quite possible that these processes, rather than the fears themselves have given our ancestors adaptational advantages and have been passed on amongst generations. Therefore, neither assuming inborn fears is necessary, nor the non-associative learning is the mechanism of fear learning. The debate on the associative and non-associative fear learning accounts is extensive and beyond the scope of this review. (See the articles of [the journal of] *Behaviour Research and Therapy*, Volume 40(2) for more discussion on this debate).

To sum up, the evaluation of the evolutionary explanations of fear acquisition, three approaches to this issue can be identified in the contemporary fear learning theories. In Mineka and Zinbarg's (2006) model, the prepared fears are endorsed, and it seems that they agree with Seligman's (1971) contention that acquisition of phobias may occur through classical conditioning, but if the organism is not physiologically predisposed to learn fear of a stimulus, such a stimulus may not be conditioned, or the

fear acquired would be short lived and would quickly extinguish. Davey (2008) takes a cautious position about attributing evolutionary roots to fears. Although he believes in evolutionary adaptive functions of some phobias, such as animal, height, and water phobias (2002), he warns that attributing evolutionary reasons to fears is easy but verifying the claim empirically will be very difficult. Finally, in Field's (Field, 2006b; Field & Purkis, *in press*) model it is believed that CS does not necessarily need to be of biological and evolutionary significance, and although the nature of CS plays a role in facilitation of fear learning, the facilitation is related to each person's learning history. None of these models agree with the existence of a non-associative fear pathway.

1.2.3. Multiple pathways to fear acquisition

It was discussed in the previous section that fears of both arbitrary and fear-relevant stimuli can be learned through conditioning. It is now widely accepted that conditioning is not the only way of learning fears. As the first attempt to systematically formulate different pathways to fear learning, Rachman (1977) proposed that the pathways can be divided into direct and indirect ones. He defined conditioning as the direct pathway to fear, and vicarious learning (also called as modelling) and information/instruction as indirect pathways. In his theory, an association between a stimulus and a traumatic outcome not only can be learned by direct conditioning episodes, but also through the processes of observing someone else's fearful interaction with a stimulus, and receiving verbal threat information about the stimulus. Both types of association can result in fear acquisition, however, fears that are learned through indirect pathways are normally less intense and extinguish more easily than the fears acquired through direct traumatic experiences. Nevertheless, if the association is experienced repeatedly, indirect learning may also result in intense fears (Davison, 1998).

Before Rachman incorporated observational learning as an indirect fear pathway in his theory, there was research (e.g., Bandura & Rosenthal, 1966; Bandura, Ross, & Ross, 1963; Bandura, Blanchard, & Ritter, 1969) indicating the influence of modelling and vicarious learning in emotional responding, including fear related reactions. Moreover, if observational learning is effective in correcting phobias (e.g., Bandura, et al., 1969), then Rachman argued that it can be effective in acquiring phobias.

There are other findings that support vicarious learning as a pathway to the acquisition of fears and phobias. For instance, the fact that phobias tend to run in families can be due to the involvement of both genetic factors and the effect of shared family environment (Gregory & Eley, *in press*), however, according to Davey (1997) there is evidence suggesting that the main mechanism of such a transmission is the process of vicarious learning. Also Mineka and Zinbarg mentioned the case of a boy who developed a severe vomiting phobia by watching his grandfather vomit while dying. He even once contemplated suicide in his adulthood when he was feeling nauseous and thought that he was going to vomit (e.g., Mineka & Zinbarg, 2006).

Unlike the observational learning, informational/instructional learning had not been conceptualised as a potentially independent fear pathway before Rachman proposed his theory of indirect fear pathways. Rachman (1977) believed that acquiring fears by verbal transmission of information occurs frequently in our lives. He argued that transmission of information, including information about dangers, is an inherent part of people's life, especially during early childhood when continuous information giving by parents and peers is a normal part of child-rearing. Therefore, it is quite probable that receiving information about how dangerous an object, situation, or activity is underlies most of our everyday life fears. Despite such obvious influence, according to Rachman, this fear pathway has been surprisingly ignored.

After Rachman's proposal, several studies have been conducted to examine the theory, and there is now an abundance of research on indirect fear pathways using retrospective and prospective methodologies. In the following this research will be briefly reviewed.

1.2.3.1. Retrospective studies on pathways to fear learning

A general review of the retrospective studies of Rachman's fear pathways has been done by King, Gullone, and Ollendick (1998). There are also more recent and specific reviews of the modelling and vicarious learning research (Askew & Field, 2008), and the informational/instructional learning research (Muris and Field, 2010). In general, the retrospective research is supportive of Rachman's formulation of direct and indirect fear pathways, and has shown that all pathways, alone or in combination, have been ascribed in different studies as the origin of fears and phobias. This in general endorses the viability of the pathways.

For instance, Ollendick and King (1991) found that majority of children between 9- and 14-year attributed their fear onset to the indirect pathways, and fewer children did so to direct conditioning. However, in cases of severe fears, it was more probable that conditioning or a combination of indirect pathways mark the emergence of the fears. As another instance, in Muris, Merckelbach, and Collaris' (1997) study children reported having more negative experience related to the information pathway (hearing threat information about their feared stimuli) than the other two pathways. However, when they were asked to specify which experience caused the start of their fears, it was more probable that children attribute their fear onset to a direct conditioning experience than the indirect pathways.

These findings were consistent with Rachman's predictions, nevertheless, there are some studies inconsistent with the predictions. For instance, in Doogan and Thomas' (1992) study, severe fear of dogs was attributed more to indirect pathways than conditioning. In this study, dog fearful child participants more than the non-fearful group reported being warned about dog attacks by their parents, and being distressed by the stories of the attacks broadcasted on the media. Moreover, the dog fearful adult participants did not report traumatic experiences more than the non-fearful adults group. Such studies suggest a more prominent role of indirect pathways in the acquisition of severe fears, which is inconsistent with Rachman's theory. Nevertheless, in these studies the origin of fears has been ascribed to one or another of the fear pathways, and in general, they support Rachman's theory.

1.2.3.2. Prospective studies of the verbal information pathway

Field, Argyris, and Knowles (2001) criticised the previous studies on Rachman's fear pathways theory for three main issues: employing retrospective methods, using forced choice measures, and lack of control groups. According to them, the main problem with these studies is that the participants are asked to specify one of the three pathways as their fear origin after around 10-20 years of the onset of their fear. Such self-reports are prone to memory bias and forgetting potentially important learning episodes and details, which can especially occur for the indirect learning experiences. Because such indirect experiences are less traumatic and emotion provoking than the direct conditioning, they may be forgotten more easily than the traumatic events involved in conditioning. The second issue with the retrospective studies is that these studies are typically based on the *a priori* assumption that the pathways actually exist,

and participants are forced to ascribe their learning experiences to one of the three pathways. A limitation of the research design is the third problem in these studies, because in these studies non-fearful control groups to compare against which the distribution of learning experiences have rarely been used. Field et al. concluded that based on these limitations, the evidence supporting the *causal role* of Rachman's indirect pathways had been equivocal, and to test the plausibility of the pathways, it is necessary to develop prospective paradigms in which information and modeling are manipulated and their effects on fear acquisition are assessed.

When Field et al. made these criticisms, the suggested prospective methodologies had not been used to research fear learning by receiving information/instruction, however, a number of studies had investigated the effect of modelling in fear learning by employing laboratory prospective methods. Namely, Bandura and his colleagues (e.g., Bandura & Rosenthal, 1966) had shown the effectiveness of vicariously experiencing noxious events (i.e., witnessing someone else receiving electrical shocks) in aversive conditioning of a neutral stimulus (a buzzer sound) in adult humans.

The other important example of the use of prospective methodology in observational learning is a series of ingenious studies conducted by Mineka and her collaborators on rhesus monkeys (e.g., Mineka, Davidson, Cook, & Keir, 1984; Cook, Mineka, Wolkenstein, & Laitsch, 1985). Cook et al. (1985), for instance, found that laboratory reared monkeys who had not seen any snake before, and were not initially afraid of them, rapidly developed a phobic-like reaction to them simply by observing a wild-reared monkey displaying fear reactions to snakes. The monkeys acquired significant fear of snakes after only 4 to 8 minutes of observing the wild-reared monkey's fear reactions, and three months later the fear had not extinguished in them. On the other hand, if the monkeys first watched wild-reared monkeys' non-fearful reactions to snakes, they did not acquire fear of snakes even when they later observed fear responses of the monkeys in their encounter with snakes. Therefore, it seems that they were immunized against developing snakes fear through this process (Mineka & Cook, 1986).

Field et al. (2001) developed a prospective method to study the indirect pathways to fear learning in humans. In this paradigm, two monster dolls, which were identical in every aspect except colour, and were not representative of an actual creature, were used as novel stimuli. The participants of this study were British primary school children, aged between 7 and 9 years (in all of the studies by Field and his colleagues which are

reviewed in this section similar samples have been used). In the Experiment 1 of this study, half of the sample was allocated to the information pathway condition, and the other half to the observational learning condition, and in the Experiment 2, only the information pathway was examined.

In the information receiving condition, half the participants heard a negative story about one of the dolls and a positive story about the other doll, and the other half heard the stories in the opposite order. The participants' fear attitudes towards the monster dolls were measured by the Fear Belief Questionnaire (FBQ, Field, et al., 2001) before and after they heard the stories. This 18-question-test was constructed in this study specifically for this purpose (i.e., to measure the participating children's attitudes towards the dolls). Both experiments indicated that verbal threat information can significantly change children's fear beliefs about novel stimuli, and that the information provided by adult figures is more effective in changing children's fear beliefs compared to information given by a child.

Field and Lawson (2003) improved on this paradigm by replacing the monster dolls with pictures of three real animals (Australian marsupials), which were unfamiliar to the participants of the study. In this study, each participant received threat information about one of the animals, positive information about the second animal, and no information about the third one, and the change in their beliefs about the animals was tested using a new version of the FBQ (the questions of which were adjusted for the novel animal stimuli) before and after receiving the information. Also an affective priming test – the Implicit Association Task (IAT, an adapted version of the task constructed by Greenwald, McGhee, & Schwartz, 1998) was administered after receiving the information to implicitly test the change in the participants' beliefs. The IAT was used to ensure that the belief change was genuine and was not due to a simple conformity to the experimental demand by the participants. In addition to these measures, a behavioural avoidance measure, called the touch box task, was used to test whether the belief change would also result in behavioural avoidance. In the touch-box task the children were asked to place their hands in three different boxes, and they were told that each box contained one of the animals about which they were given one of the three types of information. The results revealed that threat information significantly increased children's fear beliefs, as indexed by both the FBQ and the IAT. Therefore, the children acquired significantly higher explicit and implicit fear beliefs towards the animal about which they received threat information, comparing with the positive and

neutral information animals. These increased fear beliefs were also reflected in the participants' avoidant behaviour, as they were significantly more reluctant to put their hands in a box, which was believed to contain the threat information animal, relative to the boxes supposedly containing the other two animals. Follow-up data also showed that these increases of implicit and explicit fear beliefs persisted for at least 6 months in the participating children (Field, Lawson, & Banerjee, 2008).

As seen above, receiving threat information about an unfamiliar animal can increase explicit and implicit fear beliefs about the animal, and can cause behavioural avoidance. Moreover, it can generate attentional bias towards the animal about which the verbal threat information is given. This was found in two studies (Field, 2006c, 2006a) in which the participating children were first given different types of information about the Australian marsupials, then their attentional bias towards the animals' pictures was measured using a pictorial dot probe task. In this task, the pictures of the three marsupials were used as the prime pictures, and the participants were asked to identify the probe that replaced the prime pictures by pressing one of the two buttons on a keypad (see the description of pictorial dot probe task in the Part 3 of this chapter). The predicted attentional bias effect, that is, identifying the probes that replaced the threat information animal significantly faster than the other two animals, was found in both studies. In one of the studies (Field, 2006c), the bias effect was found only when the probes were displayed in the left side of the screen. This, however, does not undermine Field's findings, as similar lateral attentional bias effects occurring only in the left visual field has been also found in other dot probe studies (e.g., Mogg & Bradley, 1999, 2002). The attentional bias effect found in the study by Field (2006c) lasted at least for 24 hours. In the other study (Field, 2006a), children showed attentional bias towards the threat animal's picture, but only when the picture was paired with the positive information animal's picture, and not when it was paired with the no information animal's picture. In sum, both studies indicated that the induction of fear of a novel stimulus can lead to acquiring an attentional bias toward the stimulus, and this attentional bias does not disappear after the experiment and lasts at least 24 hours.

In a more recent study, Field, Crompton and Rohani (2009) repeated the threat related attentional bias effect using a visual search study. Children were first given threat information about one of the marsupials, and no information about the other marsupial. The search task consisted of two blocks: in one block the threat information

animal, and in the other block the no information animal, were hidden in different jungle scenes. The participating children were asked to press a button on a keypad when they find the hidden animal. Both marsupials' (cuscus and quokka) pictures, and the order of the blocks were counterbalanced, and the difficulty of the detection task varied (see Chapter 3, study 2 for a full description of the jungle search task). Children detected the threat information animal significantly faster than the no information animal, indicating an attentional bias toward threat.

1.2.3.3. Interim: Relevance to the thesis

As mentioned above, inducing fear of a novel animal by giving threat information can lead to the acquisition of attentional bias towards the animal. The bias effect has been demonstrated in the past research by faster manual RTs using the dot probe and visual search paradigms. Nevertheless, the methods used in these studies have some shortcomings: although the dot probe task is a frequently used paradigm, its reliability has been questioned in different studies (see the next section for an evaluation of the dot probe task). Moreover, using manual RTs for revealing visual attentional biases only informs us about one moment of the entire time course of attention, that is, about the moment that the participant makes the manual response.

Recording eye movements when the participants are doing the visual attention tasks has increasingly been used in attentional bias studies due to its advantages. This method provides detailed information about the overt visual attentional processes, and shows how attention is deployed throughout the course of the visual search. Information such as when was the time that a stimulus was first fixated, how long this fixation lasted, how long in total the participant dwelt on a stimulus, the number of fixations on this stimulus, the pupil size when fixating the stimuli, and so forth, are some of the information that an advanced eye tracker can provide. This information can be very useful in resolving the debates on the underlying mechanisms of threat related attentional biases (see the next section for a discussion on the application of this methodology in resolving the debates on the mechanisms).

In one of the chapters of this thesis (Chapter 3), fear of a novel animal was induced in children using similar methods as used by Field and his colleagues in the aforementioned studies. Next the children's attentional bias toward the threat information animal was examined using a paradigm that is considered a reliable paradigm for measuring threat related attentional biases, that is, the eye-tracked visual

search task (see the next section of this chapter for a thorough evaluation of the most frequently used paradigms for measuring threat related attentional biases).

In one of the search tasks used in this chapter the threat information and no information novel animals were used as targets in naturalistic visual scenes. These targets were hidden in the naturalistic scenes and an active and focused search was needed to find them. In the other search task, easily recognisable images were used in image matrices in which the threat and no information novel animals were distractors. In the naturalistic search task, the efficient detection of hidden threat targets, and in the other task, the interference effect of the threat stimuli, were examined. In these tasks, manual RTs were recorded as an index of covert attention, and eye movements were recorded as measures of overt attention. As mentioned before, this method of measuring threat related attentional biases (i.e., the eye-tracked visual search task) is more reliable than the methods used in the previous studies to test the induced biases (i.e., the dot probe task, and manual RTs). The aim of these studies was to examine the visual attention deployment patterns associated with newly acquired threat related attentional biases. The results were then compared against the visual scanpath patterns associated with naturally occurring attentional biases (e.g., attentional bias toward fear-relevant animals and threatening facial expressions) to specify the characteristics of the induced biases.

In the studies of Chapter 3, the samples consisted of 6- to 10-year old children. This age range is similar to the age range of the samples used in the previous studies by Field and his colleagues (e.g., Field & Lawson, 2003). The reason for selecting this developmental period for these studies, as argued by Field and Lawson, is that the focus of normative fears is on animals in these ages. Thus, this age range can be considered suitable for studying the development of this type of fears. Moreover, it was necessary to ensure that the threat and no information stimuli used in the FBQ and visual search tasks were novel. If the stimuli were not novel, that is, the participants knew that the animal about which they received threat information was harmless, the threat information would not have an effect. To meet the novelty requirement, employing children was advantageous, because children have shorter learning history than adults, and it is less probable that they have prior knowledge and experience of the animals about which they receive threat information. These were the main reasons to employ children between 6- and 10-year-old to study learning fear of novel animals.

1.2.3.4. Prospective studies of the vicarious pathway to fear learning

Similar to the research on verbal information, prospective methodologies have been used to show that vicarious learning is a viable pathway to fear. This pathway is not examined in this thesis, so all that needs to be said is that vicarious learning of fear has been shown in experimental paradigms in which children see pictures of novel Australian marsupials paired with happy or scared facial expressions (Askew & Field, 2007), in toddler's reactions to snakes and spiders after mothers express fearful facial expressions to these stimuli (Dubi, Rapee, Emerton, & Schniering, 2008; Egliston & Rapee, 2007; Gerull & Rapee, 2002), and in social referencing paradigms in which infants show anxiety to strangers after witnessing their socially anxious mothers' interacting with them (de Rosnay, Cooper, Tsigaras, & Murray, 2006; Murray, Cooper, Creswell, Schofield, & Sack, 2007; Murray, et al., 2008).

1.2.3.5. Interacting pathways

Retrospective (e.g., Ollendick & King, 1991) and prospective (e.g. Field and Storksen-Coulson, 2007) studies of fear pathways suggest a possible interaction between the different pathways. Using a prospective experimental method, for instance, Field and Storksen-Coulson found that verbal information had a magnifying effect on fear acquisition when preceding a direct conditioning experience. In this study, as the first manipulation, children listened to threat information about one of the novel animals, and were given no information about the other animal. This part was administered similar to the previous studies by Field and his colleagues with the exception that here there was no positive information animal. The second manipulation of this study, the direct negative experience induction, was conducted in a task similar to the touch box task. In this task, participants were asked to put their hands in two boxes which they could not see inside them, and they were told the boxes contained the threat and no information animals. However, unlike the touch box task, a furry cuddly toy was put at the back of the control box, and a weighted wooden arm was devised in the other box. This wooden arm was covered by fur and swung forward when the remote controller button was pressed. Because the box sat on a pivot, it also moved forward when the arm swung. The box was activated once the child put their hand in the box, giving the impression that the animal inside the box had moved. The moving and fixed boxes were assigned to the animals in a counter-balanced order, therefore, for half

of the participants the box supposedly containing the threat animal moved, and for the others the box supposedly containing the no information animal moved.

The outcomes of the manipulations were measured by two tasks: the FBQ, and the natural reserve task, which measures approach and avoidance behaviours indirectly. The results showed that the direct negative experience (traumatic conditioning event) without prior information had a similar effect as receiving threat information without a subsequent negative experience. However, when the direct and indirect negative experiences were combined, that is, verbal threat information was given followed by the swinging arm experience, the aversive fear learning effect was enhanced. It was concluded that verbal information influences the strength of associations formed in subsequent conditioning episodes (a moderating role) which is consistent with Davey's (1997) theory that higher fear expectancies magnify the effect of direct aversive experiences.

1.2.3.6. Interim: Relevance to the thesis

As reviewed before, research has shown that fear of, and attentional bias toward, novel animals can be acquired through receiving threat information about the animals (e.g., Field, 2006c). Similar to vicarious learning that can induce fear of snake and spider stimuli in toddlers (e.g., Gerull & Rapee, 2002), it is possible that receiving threat information about the fear-relevant animals can enhance fear of, and attentional bias toward, them. This enhanced attentional bias effect was examined in two studies of this thesis. Using a prospective paradigm to induce (or increase) fear of snakes, adult participants were given threat information about one type of snake, and no information about another type, and their attentional bias towards the snakes were measured using three different visual search tasks in the two studies. Both eye movements and RTs were recorded to examine the possible overt and covert attentional bias effects, and to explore the visual attentional patterns associated with the possible biases.

As mentioned before, in the first experiments of this thesis child samples were used and it would have been optimal to complete all the studies of this thesis by using child participants. This, however, was not possible due to serious difficulties in recruiting child participants. For this reason, we had to continue the studies of this thesis on acquiring fear and threat related attentional biases using adult samples. To study similar topic as the child studies in adults, it would have been preferable to examine learning fear and attentional bias of novel animals, such as Australian marsupials. However, it

was likely that the adult participants used in the current thesis studies (mainly university students) had prior knowledge about the animals, and knew that the threat information which was given about the animals was not true. This would have undermined the aim of the experiments. As a practical solution, instead of examining the acquisition of fear and attentional bias of novel animals, enhancing the probable pre-existing fear and attentional bias of fear-relevant animals was investigated in the adult studies. Fear-relevant stimuli, namely poisonous snakes, were selected as the experiments' stimuli because it was assumed that the made up threat information which was given about the stimuli would be more believable for snakes than for fake, or real, fear irrelevant animals. It should be noted, however, that this solution was by no means perfect, as there were some important differences between the child and adult studies. One main issue was the difference between the studies' stimuli, which in child studies were novel, and presumably fear irrelevant animals and in adult studies were fear-relevant. The processes involved in inducing fear of novel animals, and enhancing fear of fear-relevant animals might be different, and cautious should be exercised when comparing the results of such interventions. The other main issue is the difference between the age ranges of the studies' samples which leads to inevitable developmental discrepancies between the samples. For instance, as mentioned before, there is a developmental trend that children between 6- and 10- year old show fear of animals which is then replaced by social fears in adolescence. This developmental trend may influence the acquisition of fear of a new animal in childhood. On the other hand, although fear of poisonous animals is a common fear in adulthood (as reviewed before in this chapter), past research has not shown any increase in fear of poisonous animals in adulthood. Therefore, unlike the trend of animal fear in childhood, there does not seem to be any specific developmental trend to influence learning fear of fear-relevant animals in adulthood. Thus, again these differences should be kept in mind when comparing the results of acquiring fear of the two types of stimuli in children and adults.

1.2.4. Contemporary models of fear learning

Since the formation of the conditioning account as a model to explain fear learning, several studies and observations have added to the knowledge about fear learning processes, and further clarified mechanisms of conditioning. Part of these findings and discussions has been reviewed in this section so far, including the non-random

distribution of fears, and the indirect fear pathways. In the following, the discussion on the contemporary knowledge of conditioning processes will continue, and for the ease of presentation, the discussion will be outlined in two parts: mediators and moderators of conditioning, and mechanisms of conditioning. At the end of this section some of the contemporary fear learning models will be introduced, which have attempted to incorporate these recent findings and conclusions in more comprehensive accounts of fear learning.

1.2.4.1. Mediators and moderators of conditioning

Several studies have shown that different mediating factors influence the outcome of conditioning (for more detailed discussions see Field & Purkis, *in press* ; Field, 2006b; Mineka & Zinbarg, 2006; Field & Davey, 2001; Davey, 1997). These mainly include:

- Genetic and personality factors: it seems that genetic factors act as modest vulnerability factors for phobias; moreover, people who are high in personality factors such as trait anxiety and behavioural inhibition are affected more by fears (Mineka & Zinbarg, 2006).
- Life experiences before the conditioning: these factors too play a role in the extent to which a fear response is conditioned. For instance, non-traumatic exposures to CS, and a sense of control over environment that has been acquired through life experiences, both act as invulnerability factors (Mineka & Zinbarg, 2006). Moreover, factors that affect the CS-US association, such as the verbal information that we receive about the CS, US and their association, our beliefs and expectations about the consequences of the CS, our pre-established emotional reactions to the CS all influence the conditioning outcome (Field & Davey, 2001).
- Contextual variables during conditioning: it has been shown that far more fear response is acquired through conditioning if the aversive event (US) is not escapable (Mineka & Zinbarg, 2006).
- Post-conditioning variables: there are a number of factors that moderate the conditioning response after the conditioning episode has ended. For instance, inflation effect can intensify the conditioning response. The effect happens if a more intense aversive event is experienced after conditioning, even if the aversive event is not related to US (such as being physically assaulted after a minor car accident that may cause the acquisition of car phobia). Mental rehearsal of CS-US association, and US revaluation through verbally or socially transmitted information, both can

also enhance the conditioned fear response (Mineka & Zinbarg, 2006). Moreover, factors that influence the interpretation of bodily sensations, cognitive rumination of the aversive consequences of the US, and coping strategies that neutralise the US also affect the conditioning outcome (Field & Davey, 2001).

It should be noted that here verbal information is a mediator factor that affects the outcome of fear learning in the conditioning procedure by, e.g., shaping the participants' expectations before encountering the stimulus. However, in Rachman's theory, which was discussed before, verbal information/instruction is considered as a pathway to fear independent of conditioning.

From among the mediators and moderators of conditioning, some of the cognitive factors, which seem more related to the information fear pathway, are explained more in the following. Familiarity with the feared stimulus is one of these cognitive mediators. Research (e.g., De Jongh, Muris, ter Horst, & Duyx, 1995) has found that when an individual has experienced several non-traumatic encounters with a stimulus or situation in the past, they become more resilient, and it will be less probable that they develop phobia through conditioning. For instance, people with more trauma-free past experiences with a dentist, as compared to others, are less likely to acquire dental phobia after having a painful encounter with the dentist (De Jongh, et al., 1995; Kent, 1997). On the other hand, it is more probable that a person develops phobia of a stimulus if the stimulus is associated with negative emotions before it is paired with a traumatic incident (Davey, 1997). Therefore, prior life experiences can make some individuals more vulnerable, and some others more resilient to developing fears and phobias in conditioning episodes.

People's beliefs and expectancies about the stimuli involved in conditioning are also considered as a cognitive mediator in developing fears. These pre-established beliefs and expectancies can increase or decrease the likelihood of conditioning to fear, and can provide an explanation for part of the failures in acquiring fear through conditioning. For example, it may be the case that positive or less fearful expectancies of a normally frightening event (i.e., the US) protect people from being conditioned to fear of a neutral stimulus (i.e., the CS). Such expectancies can be formed by receiving positive information about the stimuli and aversive events (Rachman, 1977). The same outcome can be expected when people devalue the negativity of an aversive event by using protective coping strategies (Davey, 1997).

1.2.4.2. Mechanisms of conditioning

The advances in our knowledge about conditioning have further clarified the actual mechanisms of this learning pathway. A detailed discussion on these advances was presented by Field (2006b), the main topics of which were:

- The conditioning association is formed between the CS and US (between the potential fear object and the trauma), rather than between CS and UR (between the potential fear object and the organism's reaction);
- Conditioning depends on the person's past experience of the CS and the trauma, and whether the person has a trauma-free experience of the fear object;
- A strong association between the CS and the CR can happen even after one conditioning occasion;
- The CR and UR can be different; a CS can elicit several responses that are relevant to the US but may not be the same as the response followed by the US. For instance, rats have agitated reactions to electric shocks, such as jumping, squeaking, and increased heart rate. However, their reactions to a tone paired with electric shock are the opposite anticipatory reactions, such as decreased heart rate and "freezing;"
- Conditioning can occur without producing a CR, and it can also happen without an actual CS and US if the person has a mental representation of these stimuli;
- Extinction can happen at a behavioural level even though the CS-US association still exists;
- Traumatic events might not be traumatic for the person at the time of conditioning;
- The nature of the CS matters: evolutionary accounts of fear acquisition (e.g., preparedness theory proposed by Seligman, 1971) suggest that fears are more easily acquired to stimuli that have been threats to our survival in our evolutionary past.

1.2.4.3. An outline of the contemporary behavioural accounts of fear learning

Some conditioning-based fear learning models have been proposed to incorporate this knowledge in a coherent and comprehensive account. Davey's (1997) and Mineka and Zinbarg's (Mineka & Zinbarg, 2006) models are two of these models that are based on conditioning model (i.e., the CS-US association is the core of the models) yet acknowledge the role of the other mediating and moderating factors in fear acquisition through conditioning. In general in these models, the factors that influence the conditioning episode outcome have been discussed in three general categories. As pre-

conditioning factors, the individuals' prior knowledge and experiences about the CS and US (which include their previous informational and vicarious learning experiences), their expectancies of the learning outcome, and the genetic and personality factors are all taken into account as the factors that people bring with them to the conditioning episode. As the contextual factors, that is, the factors that take effect during the conditioning episode, controllability of the aversive event has an important impact on the learning outcome. This factor means whether or not the individual who is experiencing the aversive event can control the situation or escape it. As the post-conditioning factors, that is, the factors that can influence the CR following the learning episode, factors such as receiving positive information about the aversive stimuli, the presence of inhibitory stimuli, and the individuals' personal skills in coping with their experiences following the conditioning episode can decrease the aversive effect of the US. In contrast, negative information, cognitive rehearsal of the traumatic experience, and poor coping skills can increase the adverse effect of the US.

Field's Model (Field, 2006b; Field & Purkis, *in press*) is the other contemporary fear learning model which is similar to the models mentioned above in that it takes into account the factors which may mediate and moderate the conditioning episode's outcome. However, Field and Purkis' (*in press*) model has some differences with the other two models, namely in the role that it considers for mental representations of the CSs and USs. They argue that the link between the CS and US can be formed between the mental representations of the stimuli (not the physical stimuli themselves). Thus, the learning resulted from indirect pathways can also be considered as conditioning, in the sense that a link between CS and US has been formed. For instance, learning the fear of a novel animal through receiving threat information is a conditioning process in which the novel animal is associated with threat information, which is a mental representation of threat. In vicarious learning, such mental representation of threat is based on the individual's interpretation of the others' reactions.

In Field and Purkis' view, fear learning in humans often is qualitatively different from fear learning in animals. In humans, often higher-order cognitive processes are involved in fear acquisition. Only when fear is learned through direct conditioning and the real overlapping of actual CS and US is experienced, the learning experience is close to the primitive forms. In other cases of conditioning, and in the cases that fear is learned through indirect pathways, mental representations of CS and US are necessarily needed and higher order cognitive functions will be involved. In animals, on the other

hand, such an overlapping experience of the actual CS and US is always the case, therefore conditioning is the only mechanism of their fear acquisition (with the exception of primates who learn fear vicariously).

Thus, this model suggests that all three pathways can establish a mental link between a stimulus (CS) and a traumatic outcome (US), therefore, the indirect associations are also mediated and moderated by the same factors that mediate and moderate direct conditioning links. The model also contends that all the pathways have the potential to cause intense fears and phobias. According to Field and Purkis, although it is more probable that a direct personal traumatic experience with an entirely novel CS may result in a phobia than the experience of hearing some frightening information about the CS; it is quite possible that sustained learning experiences through indirect pathways also result in clinical levels of fear. They argued that the results of prospective studies on indirect fear pathways, which were reviewed in this section, support this suggestion. The instances they mentioned are from the research that has found that vicarious and informational learning pathways can cause fear at a level that is indicated by all three Lang's response system (Mineka, et al., 1984; Askew & Field, 2007; Field & Lawson, 2008; Field & Schorah, 2007), and that the verbal information and vicarious learning pathways can cause the formation of implicit association between a CS (novel animal) and threat (Askew & Field, 2007; Field & Lawson, 2008; Field & Schorah, 2007).

It is worth noting that although the research has shown that clear signs of fears are displayed to the fears acquired through indirect pathways, more evidence is needed to conclude phobias (in their clinical definition) have been acquired through these pathways. Providing such evidence will need sophisticated research design which will be difficult, as inducing phobias prospectively is not an option for obvious ethical reasons.

1.3. Threat related attentional biases

Two main types of threat related attentional biases are the biases towards threat related facial expressions, mainly angry faces, and the ones towards feared animals, mainly snakes and spiders. In the present review, the paradigms that have frequently been used to investigate the biases, that is, the emotional Stroop, dot-probe, and visual search paradigms, are briefly introduced and contrasted, and the results of the research

in which the visual search paradigm and the eye tracking methodology have been used are presented in more detail. The review begins with a brief discussion on attentional bias as a part of information processing dysfunctions. Although the results of this thesis' studies have some implications for the development of attentional biases, as Field and Lester (2010) pointed out, little research has been done to address the question of how attentional biases emerge and develop. This issue, therefore, will not be discussed in the present review. See this article (Field & Lester, 2010) for a discussion of the development of information processing biases, including attentional biases.

1.3.1. Threat related Attentional Bias as an Information Processing Abnormality

Cognitive theories of emotional disorders have emphasised on the role of information processing in emotional disorders, and have suggested that emotional disorders are associated with specific abnormalities in different stages of information processing, that is, attention, interpretation and recall. For instance, Beck (e.g., Beck, 1979; Beck, Emery, & Greenberg, 1985) predicted that people in depressed and anxious mood states demonstrate mood congruent biases in cognitive processing. An abundance of research has supported the predictions and has shown that information processing biases are associated with a range of psychopathologies including depression, anxiety and phobia (Gerdes, Alpers, & Pauli, 2008; Gotlib, Krasnoperova, Yue, & Joormann, 2004; Mogg, Bradley, Miles, & Dixon, 2004). Anxiety disorders have probably been the main focus of interest in this regard (Calvo, Averó, Castillo, & Miguel-Tobal, 2003). As reviewed by Williams and his colleagues (Williams, MacLeod, Watts, & Mathews, 1988, 1997) numerous studies have provided strong evidence that anxiety is associated with specific types of such information processing biases. For instance, at attention level, anxious and spider phobic individuals show attentional biases toward threatening facial expressions (e.g., Horley, Williams, Gonsalvez, & Gordon, 2004) and spider images (e.g., Pflugshaupt, et al., 2005) respectively. At interpretation level, highly anxious children interpret non-hostile or ambiguous vignettes as threatening more frequently than their non-anxious counterparts (Bell-Dolan, 1995), and individuals' anxiety scores are positively associated with threatening interpretation of ambiguous homophones, such as dye versus die (Hadwin, Frost, French, & Richards, 1997). Finally, at memory level some types of anxiety disorders, such as panic disorder,

have found to be associated with explicit memory bias, and other types, such as generalised anxiety disorder, with implicit memory bias toward the disorder-relevant memories (Williams, et al., 1997). There are, however, debates about the strength of the evidence for anxiety related memory biases (see, e.g., Mogg, et al., 2004).

Attentional bias is a prioritization of attention to emotionally salient stimuli in the environment (Riskind, 1997). Attentional bias occurs during the early stages of information-processing and reflects an unintentional, effortless, relatively fast process that takes place without awareness (MacLeod, Mathews, & Tata, 1986). Therefore, a person with attentional bias toward a specific set of stimuli selectively attends to these stimuli, which are subsequently processed further. Anxious individuals show this prioritisation to threat-related stimuli. They are hypervigilant to threat cues and allocate greater cognitive resources to threatening stimuli than to other environmental stimuli (Mathews, 1990; Mathews & MacLeod, 1986).

The prioritisation of attention allocation to threatening stimuli in anxious people is assumed to play an important role in development, maintenance, and even aetiology of anxiety disorders (Beck, et al., 1985; Williams, et al., 1988, 1997). In this model, anxiety leads to increased hypervigilance for threat, a greater level of threat detection leads to increased anxiety which, in turn, leads to increased hypervigilance, and so on in a vicious circle which suggests maintaining anxiety (Dalgleish, Moradi, Taghavi, Neshat-Doost, & Yule, 2001). The role of attentional biases in the aetiology of anxiety has also received considerable support by the studies which have found that inducing anxiety related attentional biases increase vulnerability to anxiety (Mathews & MacLeod, 2002), and that modifying the anxiety related attentional biases results in decreasing anxiety levels (Dandeneau, Baldwin, Baccus, Sakellaropoulou, & Pruessner, 2007; Schmidt, Richey, Buckner, & Timpano, 2009). Thus, attentional biases may not be simply by-products of the disorders, but may actually play a causal role.

For this reason, some researchers, such as Muris (2007), have classified attentional bias as a maintaining factor for anxiety and fear. Moreover, he considered temperamental/personality factors such as trait anxiety and neuroticism as vulnerability factors for anxiety. This is similar to Spielberger's (1972) conceptualisation of anxiety, according to which, trait anxiety predisposes individuals to respond anxiously to potentially threatening and dangerous situations. According to him, people who are high in trait anxiety have a low threshold to react anxiously to threat stimuli, therefore, the higher the trait anxiety, the more likely the person displays anxiety response (anxiety

state in his own term). Neuroticism as another vulnerability factor for anxiety, is considered (e.g., Zinbarg & Barlow, 1996) as a higher order factor, relative to trait anxiety, which predisposes individuals to respond with negative affects (in a broad sense) to general aversive situations (including threatening situations). Based on this definition, these two vulnerability factors are overlapping, and higher levels of neuroticism, similar to trait anxiety, should be associated with anxiety states. This has been supported in research (e.g., Ehrler, Evans, & McGhee, 1999). Therefore, in this view, anxiety is predisposed by the stable subtle personality factors such as trait anxiety and neuroticism, and maintained by information processing tendencies such as attentional bias.

To re-state the argument more briefly, predispositional factors, such as trait anxiety, enhance the likelihood of experiencing anxiety and phobia in response to their relevant situations (when exposed to threat, or in a fear learning episode). By developing anxiety or fear, people also acquire attentional bias toward the threat relevant stimuli, and these attentional biases may be maintaining factors which play a role in the endurance of the people's emotional disorders.

1.3.2. Measuring threat related attentional biases

The threat related attentional biases have been researched by employing different paradigms, most of which rely on visual attention. The most frequently used paradigms include the emotional Stroop, the dot-probe, and the visual search tasks.

1.3.2.1. The emotional Stroop paradigm

In this paradigm, participants are shown different words, presented in different colours whose meaning may have positive, negative or neutral valence. Participants are instructed to name the colour of the word, and ignore their meanings. In the pictorial version of the paradigm, pictures of the stimuli are displayed in different colours and participants are asked to name the colour of the pictures while ignoring their contents. Both variants of this paradigm have been used to examine fear and anxiety related attentional biases in adult and child populations. These studies in general have found attentional bias effects (i.e., retarded colour naming) toward fear- and anxiety-relevant stimuli in anxious and non-anxious, and phobic and non-phobic individuals (for reviews of adult studies see Mobini & Grant, 2007; Williams, Mathews, & MacLeod, 1996; and

for a review of child studies see Nightingale, Field, & Kindt, 2010). There are some notable findings in this research. For instance, in a study by Richards, Richards, and McGeeney (2000) threat related attentional biases were found to have a linear relationship with anxiety scores, thus, the higher the children's trait anxiety, the more they delayed in colour naming of threat-relevant words. Moreover, it was found in other studies (Kindt, Bierman, & Brosschot, 1997; Kindt, van den Hout, de Jong, & Hoekzema, 2000) that attentional bias to spider related words was not specific to spider phobic children, and non-phobics also showed attentional bias to the stimuli. Finally, attentional bias in spider phobic adults was eliminated after they received short term behaviour therapy using techniques such as desensitisation and exposure (Watts, Mckenna, Sharrock, & Trezise, 1986; Lavy, Van den Hout, & Arntz, 1993). An evaluation of this task is presented later in this section.

1.3.2.2. The dot probe paradigm

The dot probe paradigm was originally designed by Macleod, Mathews, and Tata (1986) in which words were used as threat relevant (either physical or social) and neutral stimuli. In this task a pair of neutral and threat-related stimuli (words or pictures) is presented for a short interval on the screen in each trial, then in the vicinity of one of the stimuli a small dot appears, and participants are instructed to press a button on a response key as soon as they detect the probe. A fast probe detection is assumed to index the person's attention allocation to the stimulus that had previously been in the location of the dot. Therefore, if the probe detection is faster when the probe has appeared in the location of the threat related stimulus, it is interpreted as the attention being previously allocated to the threat stimulus, hence, attentional bias to the stimulus, whereas the opposite response pattern would be interpreted as attention being directed away from the threat.

The dot probe paradigm is similar to the visual cueing paradigm, which is a task that was devised by Posner (1980) and was modified for use in a number of studies to measure threat related attentional biases (e.g., Fox, Russo, Bowles, & Dutton, 2001). In the modified visual cueing tasks, a single cue (which can be a threat related word, an emotional facial expression, or a neutral stimulus) appears in one of the two locations on the screen. Next a target, such as a plus sign, appears in the vicinity of the cue on the majority of trials (valid trials), or in the opposite location on the screen on the minority of trials (invalid trials). Based on this design, if anxious individuals direct their attention

towards the threat stimuli, their RTs to detect the target will be slower on the invalid trials, and faster on the valid trials. On the other hand, if they avoid the threat stimuli, their RTs will be faster on the invalid trials and slower on the valid trials.

Numerous studies have employed these two paradigms to examine threat-related attentional biases. This research in general supports the existence of the anxiety related attentional bias. The effect has been reported in dot probe studies in both anxious adults (e.g., Ononaiye, Turpin, & Reidy, 2007; MacLeod & Mathews, 1988; MacLeod, et al., 1986; Salemink, van den Hout, & Kindt, 2007) and children (e.g., Vasey, Daleiden, Williams, & Brown, 1995) using word stimuli; and in adults (e.g., Koster, Crombez, Verschuere, & De Houwer, 2006; Mogg, et al., 2004; Bradley, Mogg, & Millar, 2000; Mogg, Millar, & Bradley, 2000) and children (e.g., Waters, Wharton, Zimmer-Gembeck, & Craske, 2008) using pictorial stimuli (for a review of adult studies see Williams, et al., 1997; and for a review of child studies see Garner, 2010). Using the visual cueing task, the attentional bias effects in accordance with the predictions have also been found in several studies (e.g., Fox, et al., 2001; Fox, Russo, & Dutton, 2000; Georgiou, et al., 2005; Koster, Crombez, Verschuere, Van Damme, & Wiersema, 2006), although some studies (e.g., Koster, Leyman, De Raedt, & Crombez, 2006) did not find the anxiety related attentional bias using this task.

Similar to the studies using the Stroop paradigm, in some studies (e.g., Waters, Lipp, & Spence, 2004) using the dot probe paradigm, the attentional bias effect was not specific to the clinical sample, and both anxious and non-anxious children and adults showed attentional bias to threat related pictures. In another study (Waters, et al., 2008) in which only anxious children showed attentional bias to threat related pictures (such as snakes, spiders, sharks, aimed guns, and injection) the effect persisted even after they received psychotherapy using the CBT method. An evaluation of the dot probe paradigm is presented later in this section.

1.3.2.3. Attentional bias toward subliminally presented threat stimuli

Subliminal and supraliminal refer to two different modes of stimuli presentation: when a stimulus is presented for very short period of time, so that the presentation time ends before the stimulus is consciously registered, the presentation mode is subliminal. When the presentation duration is long enough for the stimulus to be consciously registered, the presentation mode is supraliminal (Mogg & Bradley, 1999). It is argued that these modes indicate different phases of attention regulation: in the very early phase of

attention (i.e., when stimuli are perceived subliminally), a pre-attentive, automatic mechanism operate to direct attentional focus to the area in the perceptual field that is most significant for the organism. In later phases of attention, after stimuli are perceived consciously (i.e., in supraliminal mode), more conscious and strategic control will be applied on attention direction (Egloff & Hock, 2003). Stimuli and situations that are threat to the organism hypothetically are of such a significance to activate the pre-attentive mechanism when presented at subliminal level (Mogg & Bradley, 1999). This hypothesis has been widely tested using both emotional Stroop and the dot probe paradigms. To test subliminal attention to threat stimuli, the stimuli have been presented for durations below 50ms (e.g., Egloff & Hock, 2003), and as short as 14ms (e.g., Bradley, Mogg, & Lee, 1997), and then masked for the remaining stimuli display time, or until a response has been made. Various types of masks have been used to replace threat stimuli. To mask word stimuli in the Stroop colour naming task, and in the word variant of the dot probe task, the threat words were replaced by, for example, random strings of letters (Bradley, Mogg, Millar, White, 1995), random strings of graphic characters (Macleod & Rutherford, 1992), and Xs of the same colour (Egloff & Hock, 2002). To mask threat faces in the pictorial dot probe tasks, jumbled up faces, made by cutting and randomly reassembling neutral face features, have been used (Mogg & Bradley, 1999). These studies have found the colour naming interference effect by the masked threat related words (e.g., Bradley, et al., 1995; MacLeod & Hagan, 1992, Mogg, Bradley, Williams & Mathews, 1993), and faster detection of probes appearing in the vicinity of the masked threat related stimuli (e.g., Helzer, Conner-Smith & Reed, 2009; Mogg & Bradley, 1999) in anxious individuals. As reviewed in the previous sections, the results of the research using the Stroop and dot probe paradigms have also indicated attentional bias to threat stimuli presented supraliminally (with stimuli display times longer than 250ms). Therefore, in sum, research has shown that anxiety-related attentional bias exists at both subliminal (pre-attentive) level, and supraliminal (elaborative) level. There is, however, inconsistency in this research. For instance, in Egloff and Hock's (2002) study, no attentional bias to threat related words was found in the Stroop and dot probe task when the stimuli were presented subliminally (i.e., 17ms for the Stroop task, and 50ms for the dot probe task). However, the bias effect was found in both tasks when the stimuli were presented supraliminally (i.e., until a response was made for the Stroop task, and at 500ms stimuli display time for the dot

probe task). Despite such inconsistencies, the Stroop and dot probe tasks' literature generally supports pre-attentive bias to threat.

1.3.2.4. The debates on attentional bias mechanisms examined by the visual Cueing and dot probe tasks

Two main debates about attentional bias mechanism have been examined by the visual cueing and dot probe tasks. The first debate is about the interaction of the individual's trait anxiety level and the level of threat that is elicited by a stimulus. One theory, the biased attentional direction theory (Williams, et al., 1988, 1997), predicts that as the threat level increases, highly anxious individuals increasingly attend to the stimuli, and low anxious individuals increasingly avoid them. The shifted attentional function theory (or the cognitive motivational theory, Mogg & Bradley, 1998; Mogg, McNamara, et al., 2000), on the other hand, predicts that both high and low anxious individuals become more vigilant, and show higher attentional bias as the threat level of the stimulus increases. The results of the dot probe tasks mentioned in this part do not directly examine these predictions. However, Mogg et al. (2000) directly tested these predictions in two dot probe tasks using high threat (e.g., mutilated bodies) and mild threat (e.g., soldiers holding guns) pictures paired with neutral pictures (e.g., a person playing piano). Both low and high trait anxious individuals showed increasing vigilance as the threat valence of the pictures increased. Similar results were found in another pictorial dot probe task (Koster, Crombez, Verschuere, & De Houwer, 2006), according to which all individuals showed attentional bias to highly threatening stimuli, but individuals who were low in trait anxiety showed less attentional bias effect, as compared to high trait anxiety individuals, to mild threat stimuli. The researchers of these two studies argued in support of Mogg et al.'s cognitive motivational theory.

The other main debate is whether attentional bias effect is due to early engagement to, or difficulty to disengage from, threat stimuli. Fox et al. (2001) argued that the dot probe tasks that had been employed for examining anxiety related attentional biases were not conclusive for the two possible underlying mechanisms. According to them, the prime display times (usually 500ms) used in the tasks were long enough for the participants to change the direction of their attentions from one to another competing prime image presented in a trial. Therefore, the resulting faster response to the probe could be due to an initial orientation to, or a later holding of attention by, the prime. For clarifying the debate, they employed modified versions of Posner's exogenous cueing

paradigm (Posner, 1980) using word and schematic facial stimuli as cues and a circle as the target in five experiments. The two possible effects (orienting or disengagement) were tested by separately examining the participants' responses to the targets preceded by the valid and invalid cues: RTs to the targets preceded by valid cues indexed the orientation effect, and RTs to the targets preceded by invalid cues indexed the disengagement effect. In all of the experiments, only the disengagement effect, and no orienting effect, was found, and in all of the experiments, except for one in which word stimuli were used, anxiety had significant effect on attentional bias to threat. Similar results were found in other studies using the visual cueing paradigm (e.g., Yiend & Mathews, 2001; Fox, Russo, & Dutton, 2002; Georgiou, et al., 2005; Koster, Crombez, Verschuere, Van Damme, et al., 2006). In Broomfield and Turpin's (2005) study, eye movements were also recorded. Both high and low trait anxiety participants were slower in disengaging from threat invalid cues and showed no faster engagement in valid trials (Experiment 1), which is consistent with the previous findings. Inconsistent with the previous studies, however, high trait anxious participants showed faster disengagement from threat stimuli, than the low anxious ones (Experiment 2). The eye movement results showed that the high trait anxious participants made significantly more uninstructed eye movements towards the threat words, implying on the difficulties that anxious individuals may have in inhibiting saccades to threat stimuli. Following the use of visual cueing paradigm to test the attention engagement and disengagement effects, the dot probe studies was also adapted to examine the debate (Koster, Crombez, Verschuere, & De Houwer, 2004; Salemink, et al., 2007). This was done by adding a new condition to the task in which both members of the prime stimuli pairs were neutral. Based on this arrangement, the difference between the RTs of the all-neutral trials and the RTs of the threat congruent trials would indicate the orientation effect, and the difference between the RTs of the all-neutral trials and the RTs of the threat incongruent trials would indicate the disengagement effect. Using this variant of the dot probe task, similar results as the visual cueing task were found, and in sum, most of the results of both paradigms suggested that difficulty in disengagement from threat is the mechanism of threat-related attentional biases.

Nevertheless, there are some issues with using these paradigms to explore the fast engagement or prolonged disengagement effects. It was argued by Mogg and her collaborators that visual cueing paradigm does not differentiate the response slowing effect, which occurs in anxious individuals' manual RTs because of the exposure to

threat stimuli, from the threat-related attentional bias effect (Mogg, Holmes, Garner, & Bradley, 2008). This can also be extended to the dot probe task. In this regard, eye movement recording can be considered advantageous because it does not rely on manual RTs. This methodology has been used with the dot probe and visual cueing tasks, but it should be noted that the methodology might not be optimally informative when used with these tasks, especially when the prime/cue display time is short. This is because these tasks instructions is to find probes/targets appearing in one of the two positions on the screen, and participants might find it more efficient to respond without changing their gaze direction and by using their peripheral vision to detect the simple probe – a point that was made by Bradley et al. (2000) as a probable explanation for their findings. This methodology might be more useful when it is used with the visual search paradigm. Before reviewing the results of this paradigm, it is worth mentioning a visual attentional pattern that has repeatedly been reported in threat related attentional bias studies.

The vigilance-avoidance pattern is an attention allocation pattern which has been found using various paradigms, including the visual cueing and dot probe paradigms. In the following, some of the studies that have reported finding this pattern using the two paradigms are reviewed. In Broomfield and Turpin's visual cueing study (mentioned above) fast disengagement from, and uninstructed eye movement towards, threat stimuli were found in high trait anxious participants. They argued that these findings are consistent with the vigilance-avoidance pattern. Similarly, the pattern was reported in a visual cueing study by Koster, Crombez, Verschuere, Van Damme, and Wiersema (2006), in which, neutral, mildly and highly threatening pictures were shown to high and low anxious groups. In the cue display time of 100ms, highly anxious people showed vigilance to highly threatening cues, but in 200ms and 500ms, they avoided the mild and high threat cues. In an eye-tracked dot probe study by Garner et al. (2006b), a general vigilance-avoidance effect towards emotional (happy and angry) faces was found. Socially anxious and non-anxious participants were shown pairs of happy-neutral, angry-neutral, and neutral faces-household objects as prime pictures for 1500ms. In high social-evaluative stress situation, high social anxious participants were quicker to direct their gaze towards emotional (happy and angry) faces, then turned their gaze away from the faces, relative to their non-anxious counterparts. This effect, however, was found for both happy and angry faces.

Some mixed results with regard to the vigilance-avoidance pattern have also been found in other investigations. In a study that was designed to examine the vigilance-avoidance pattern (Mogg, et al., 2004), only vigilance effect was found to be related to anxiety. In this study, high and mild threat pictures were paired with non-threat scenes, and were displayed as prime pictures for 500ms and 1500ms to high and low trait anxious, and blood-injury fearful participants. The threat pictures covered a range of threats such as mutilation, injury, death, violence and warfare. The high threat scenes (e.g., mutilated bodies) were used to provoke an aversive reaction and reveal a possible vigilance-avoidance effect. The high trait anxiety participants showed only an initial orientation (vigilance) effect towards the high threat pictures in the shorter prime exposure duration, but in the longer exposure time, they did not show the predicted avoidance effect even to the high threat scenes. However, the blood-injury fearful participants showed both initial orientation (vigilance) in the shorter prime display times, and avoidance in the long display times, towards the high threat pictures. Some other studies (Bradley, Mogg, Falla, & Hamilton, 1998; Bradley, et al., 2000; Mogg, Millar, et al., 2000) have also reported only the vigilance (but not the avoidance) effect towards threat stimuli. In the last two of these studies, the eye movements were also recorded, and in Bradley et al.'s study, the eye movement and RT data were consistent, but in Mogg et al.'s study, the vigilance effect was found only in the eye movement results.

It is believed that the vigilance-avoidance pattern plays an important role in the maintenance of anxiety disorders: vigilance leads to excessive threat detection, and avoidance prevents habituation with the stimuli (Mogg, et al., 2004). The vigilance-avoidance pattern and other threat-related attention allocation patterns have been documented in the eye-tracked visual search studies in more detail and will be discussed later in this section.

1.3.2.5. Evaluation of the Stroop and dot probe paradigms

As reviewed before, in general, both the emotional Stroop and dot probe studies have reported threat related attentional biases consistent with the theoretical predictions. However, inconsistencies in the results of these studies are not uncommon. The unexpected and inconsistent results have led some researchers to consider the emotional Stroop (Vasey & MacLeod, 2001) and the dot probe (Mogg, Bradley, et al., 2000) paradigms as unreliable and fragile measures of anxiety related attentional biases.

In some studies where both tasks have been administered on the same participants, the results of the tasks were totally uncorrelated (e.g., Dalglish, et al., 2003). In some studies, anxiety related attentional biases were found using the Stroop task, but not the dot probe task (Mogg, Bradley, et al., 2000), and in some studies using the dot probe task but not the Stroop task (Dalglish, et al., 2003). This may mean that the tasks probably tap different underlying cognitive processes.

In evaluating the Stroop task, In-Albon and Schneider (2010) argued that it is not clear whether the delay in the colour naming of threat related stimuli in this task is due to the bias in attention to the stimuli, or it originates from a negative emotional reaction caused by the threat stimuli in anxious people. They suggested that the dot probe paradigm has been more successful than the Stroop task in demonstrating threat relevant attentional biases in anxious people. However, Schmukle (2005), who assessed the psychometric reliability of the dot probe task in non-clinical adults, concluded that this paradigm is a totally unreliable measure of attentional bias in such samples. He found low internal consistency, and low retest reliability in a one-week retest interval, in both pictorial and word-based versions of the task and using both social and physical threat as the prime stimuli contents.

1.3.2.6. The visual search paradigm

Searching in the stimulus arrays or visual scenes that are presented on a screen is the common task in this paradigm, and depending on the type of the search task, the task's instructions vary. The instruction can be searching for a particular target in the images; for a specific category of targets; or for a deviant image amongst other homogenous images in the arrays. Moreover, in some search tasks, the instruction is to freely view the presented visual scene without specifying any search target.

The stimulus arrays also take various formats in visual search tasks. For instance, the stimuli can be separate circular images that are presented in circular arrays (e.g., Hadwin et al., 2003; Derakshan & Koster, 2010); separate square images presented as adjacent, or separate grid locations in square matrices (e.g., Rinck, Reinecke, Ellwart, Heuer, & Becker, 2005; Öhman, Flykt, & Steves, 2001); or target images that are added to natural visual scenes (e.g., Pflugshaupt et al., 2005). The participants' response time (RT) and the accuracy of their responses are the output indices of visual search tasks.

The two most frequently used types of these search task variants, which have also been used in the current thesis experiments, are the target search and the deviant

search tasks. In the target search task, the instruction is to search for a pre-specified target, and the target image is presented among non-target images. The non-target images can be fillers or distractors, depending on their emotional valence. The non-target image is filler when it is assumed to be emotionally neutral and causing no interference in the instructed task, that is, in detecting the target. In this variant of search tasks, it is expected that the targets with emotional valence will be detected faster than the control targets. The non-target image is a distractor when it is emotionally valenced, and presumably interferes with detecting the target. Therefore, when a threat related stimulus is presented as the target among filler stimuli, it is expected that detecting it occurs faster than detecting a non-threat target. However, if the threat stimulus is presented as a distractor, and the task's instruction is to find a non-threat target, it is expected that finding the target will be delayed because of the presence of threat related distractor.

In the deviant (or odd-one-out) search task, the instruction is to specify whether all images of a stimulus array are similar, or there is a different image amongst the homogenous background images. In this task, therefore, the target present arrays are the arrays in which a deviant image is presented (e.g., when in a 9-cell matrix, a spider image is displayed amongst 8 mushroom images), and the target absent arrays are the ones in which all the images are similar (e.g., all the 9 cells of the stimulus array are mushroom images).

Similar to the target search task, both speeded target detection effect and the interference by distractor effect can be examined by the deviant search task. For instance, the speeded detection of a threat target is expected when the image is presented as a deviant image amongst non-threat background (homogenous) images; and a delayed response is expected when a non-threat target is presented as the deviant image amongst threat background images. The difference between the target search and deviant search variants in examining the interference effect is that in the target search variant, along with the target and distractor images, filler images can also be used, and a single image can be used as the distractor. However, when examining the interference effect using the deviant search variant, due to the specific instruction of the task, no filler image can be used in the stimulus arrays, and except for the target, all the images of the array will be distractors. In this variant of search tasks, therefore, the emotionally valenced distractor images (e.g., threat related images) are presented massively in each

stimulus array, and the array consists of several homogenous distractor images and a deviant neutral target.

Finally, there is an essential difference between the target search and deviant search tasks in terms of the cognitive processing functions involved in the task: the processing mechanism is assumed to be ‘top-down’ when the instruction is to find a pre-specified target, as in the target search task, whilst the mechanism is assumed to be ‘bottom-up’ when no target is pre-specified, as in the deviant search task (Donnelly, Hadwin, Manneer, & Richards, 2010).

1.3.2.7. Recording visual scanpaths as a measure of attentional bias

With increasing distance from the fovea, visual acuity decreases dramatically. Thus, we continuously need to perform saccadic eye movements to focus our fovea on one region in the visual field at a time. Moreover, our cognitive resources are limited, and the information contained in a natural visual scene is far too much to be processed by our cognitive system (Hutton, 2008). Therefore, we need to direct our limited cognitive resources to the regions in the visual field which contain the information most relevant to our current interests. This is the function of attention. There is a close link between foveal gaze directions and covert attention orientations, and gaze direction has been suggested to be an ecologically valid objective measure of covert attention (Rayner, 1978). It has also been confirmed in several studies that eye tracking has a good reliability using different methods of testing reliability, such as internal consistency and test-retest (In-Albon & Schneider, 2010). Therefore, it can be concluded that the eye movement recording is a suitable measure of spatial attention, and as Bögels and Mansell (2004; as cited in In-Albon & Schneider, 2010) suggested, this method might be the most direct way of examining selective attention.

The most important advantage of the eye tracking methodology is that it provides a continuous measure of gaze direction (hence spatial attention), whereas assessing visual attention by manual RTs is similar to taking a snapshot from the course of attention (Hermans, et al., 1999; In-Albon & Schneider, 2010). In other words, when attention is indexed by RTs, the information obtained about attention is limited to the time that the response has been made, and we cannot know where visual attention has been directed to before or after this time. Recording eye movements, especially by advanced eye tracking systems, provides us with vast amount of information about the entire course of overt attention orientation.

The main limitation of researching visual attention by the eye tracking methodology is that an eye tracker can only track the overt attention, and the coordination of overt and covert attention orientations is assumed in the eye movement recording studies. However, it has long been known that the gaze and selective attention are not always co-located, and it has been shown in some studies that these two can be dissociated under experimental conditions (Hutton, 2008; Hermans, et al., 1999). Nevertheless, as mentioned above, there is usually a close link between spatial attention and gaze direction; therefore, inferring covert attention orientations from gaze directions is reasonable. Moreover, recording manual RT data, as an index of covert attention, in the visual search tasks along with eye movement data may be a helpful strategy which enables us to examine both overt and covert attention orientations.

The eye tracking methodology has been frequently used in threat related attentional bias studies alongside the visual search paradigm. Moreover, the methodology, as mentioned before, has also been used with the dot probe (e.g., Koster et al., 2006) and visual cueing (e.g., Broomfield & Turpin, 2005) paradigms. However, as discussed before, recording visual scanpaths might not be optimally informative when used with the dot probe and visual cueing tasks because of the limitations of these tasks in measuring overt attention. These limitations are due to the specific designs of these tasks, such as the way the competing stimuli are presented in the tasks. For instance, to respond to the dot probe task correctly, changing gaze directions may not be necessary, and participants may be able to respond to the trials without directing their gaze to the threat stimuli (Bradley et al., 2000). In such circumstances, therefore, recording eye movements will provide no additional information about attention deployment to each one of the stimuli presented. This is not the case for the visual search tasks in which the participants usually need to actively search the stimulus arrays to be able to make a correct response, thus, their visual scanpaths can be a useful source of information about the underlying attentional processes. It can, therefore, be concluded that employing the visual search task, and recording both eye movements and RTs is currently the most informative method of measuring threat related attentional biases. This method has been frequently used for examining threat related attentional biases.

As discussed before, Öhman, Mineka and their colleagues suggested a fear module in the nervous system that favours processing of fear-relevant stimuli (e.g., Öhman & Mineka, 2001). They proposed that the threat that activates this brain module could originate from other species, such as poisonous and deadly animals, or from the same

species members, such as an angry person who can be a potential attacker. To investigate attentional biases to the threat stimuli, pictures of angry faces have been presented amongst other emotional facial expressions, such as happy, neutral, sad, and disgusted facial expressions, and pictures of potential fear stimuli, such as fear-relevant animals (e.g. snakes and spiders), electrical outlets, knives, and guns, have been displayed among non-feared objects, such as non-feared animals (e.g., butterfly and beetles), mushrooms, household items, and so on, in visual stimulus arrays.

In this section, first the visual search studies in which facial stimuli have been used are reviewed. Due to relevance to one of the studies of this thesis, the child anxiety research is the focus of this review. Next in this section, the visual search studies that have investigated attentional biases to fear-relevant stimuli in child and adult populations are reviewed. In this section, the research in which the eye movement recording methodology has been used is reviewed in more detail.

1.3.3. Visual search for facial stimuli

Human facial expressions have been used as stimuli in visual search studies using general (e.g., Öhman, Lundqvist, & Esteves, 2001) and clinical (e.g., Byrne & Eysenck, 1995) populations of adults. The stimuli included black and white (e.g., Hansen & Hansen, 1988; Purcell, Stewart, & Skov, 1996), and colour (e.g., Juth, Lundqvist, Karlsson, & Öhman, 2005, Experiments 1, 2, and 3) photographs, and schematic line drawings (e.g., Calvo, Avero, & Lundqvist, 2006) faces. In some of these studies (e.g., Calvo & Avero, 2005), eye movement data were also collected during the search tasks.

Most of this research has supported attentional bias towards angry faces and have found that the detection of angry faces is faster compared to other emotional expressions (e.g., Fox, Lester, et al., 2000; Öhman, Lundqvist, et al., 2001; Hansen & Hansen, 1988; Tipples, Atkinson, & Young, 2002; Juth, et al., 2005, Experiment 5). However, there are studies that have failed to find an attentional bias towards angry faces, and for instance, have found faster detection of happy faces instead (Byrne & Eysenck, 1995; Juth, et al., 2005, Experiments 1, 2, & 3; Purcell, et al., 1996, Experiments 1.1 & 1.2).

In some of these studies, the eye tracking methodology has also been used, and has yielded mixed results, in addition to revealing some specific attentional deployment patterns. For instance, in a study by Hunt, Cooper, Hungr, and Kingstone (2007), the

participants showed attentional bias to both angry and happy facial emotional stimuli. The attentional bias effect was indexed by the interference effect of stimuli in the participants' saccades. The stimulus arrays consisted of normal (i.e., angry, happy, and neutral) and inverted line drawing schematic faces, in which the inverted faces served as the control stimuli. The participants were instructed to look toward the target, which was pre-specified for each of the experiment's groups, and ignore the distractors in the array. The emotional distractors, in general, slowed down fixations on the target, although angry faces distractors did not attract any more saccades than the happy faces distractors. Moreover, no faster orientation effect was found toward angry faces as compared to happy faces when presented among neutral faces. Such a general attentional bias to emotional themes was also found in Calvo, Nummenmaa, and Avero (2008). These researchers criticised the previous research for using schematic faces (according to them, conclusions from studies using schematic faces are not generalizable to real faces), and for using limited emotional expressions in stimulus arrays. Therefore, they used colour photographs of six facial expressions (happy, surprised, disgusted, sad, fearful and angry) in an odd-one-out search task. The study's sample consisted of healthy undergraduate students. RTs were made faster and more accurately when identifying a happy, surprised, or disgusted face among the neutral faces, as compared to identifying a sad, fearful, or angry face amongst the neutral faces. The eye movement indices also showed that the visual orientation to the happy, surprised, and disgusted facial expressions was more efficient (i.e., it was more probable that the first fixation landed on these faces, and the time to first fixate on these faces was shorter) relative to the sad, fearful, and angry facial expressions. Moreover, the decision as to whether the face was different from the neutral faces was made with fewer fixations on the first group of facial expressions as compared to the second group.

A general distracting effect of emotional pictures was found in another study by Nummenmaa, Hyönä, and Calvo (2006). In this study, pairs of emotional and neutral photos were displayed to healthy adults, where the emotional pictures consisted of either pleasant (e.g., people showing pleasant affects) or unpleasant (e.g., people suffering from serious harms, or people in threatening postures such as wielding knives) photos, and neutral pictures depicted people in daily, non-emotional situations (such as sitting at a desk). The results of their first experiment revealed that it was more probable that the participants first fixate on emotional pictures, and make more fixations on these pictures relative to the neutral pictures. The second experiment of this study showed

that the probability that participants fixate first on the emotional pictures was still higher than the neutral pictures, even when they were instructed to ignore the emotional pictures, and that they fixated for a longer time in their first fixation on the emotional pictures as compared to the neutral targets.

Such non-specific attentional bias was found in anxious individuals by Calvo and Avero (2005) in another eye-tracking study. In this study, university students low and high in trait anxiety were shown pairs of control and target photos, and were asked to examine whether the valence of the image pairs were the same or different. The target pictures consisted of four categories: threat-related, harm-related, emotionally neutral, and positively valenced. These pictures contained scenes in which people were involved, and the control pictures contained inanimate objects such as buildings, vehicles, and household items. High trait anxious individuals, compared to low trait anxiety group, were more likely to fixate first on the pictures with emotional themes, and to have longer fixation durations on both harm-related and positively valenced scenes in the first 500 ms of the picture onset, indicating an early attentional engagement with the scene. High anxiety was also associated with reduced duration of fixations on the harm-related scenes in the second half of the display time, and with lower probability of the last fixations landing on the harm related scenes, which suggest anxious individuals' late avoidance of the harm-related scenes (but not the threat-related scenes).

It is worth noting that Calvo and Avero (2005) interpreted the higher probability of the first fixation on the emotional scenes as evidence for an early automatic, pre-attentive processing of the scenes, as according to them, "it implies that the viewers "perceived something" *before* "having looked at it, which fits well into this preattentive account"(p 446). They proposed that early engagement with positively valenced stimuli is beneficial for emotional well being, and might explain why a bias to positive stimuli sometimes happens with anxious individuals. Moreover, they argued that the early engagement, and faster disengagement they found for emotional stimuli, including the threat related ones, do not contradict with the slow disengagement (prolonged engagement rather than avoidance) of threats found by other researchers (Fox, et al., 2001; Fox, et al., 2002; Yiend & Mathews, 2001), and that the apparent differences are explicable in terms of the different stimuli exposure times that were used in the different studies. According to them, researchers who found late disengagement of threat-related stimuli, used short stimuli (probes and cues) presentation times in the

dot probe and visual cueing tasks, and found the effect between 250 ms and 500 ms after the stimuli onset. This is almost the same time in which Calvo and Avero found the early orientation effect in eye movement data. On the other hand, Calvo and Avero found the disengagement of harm scenes after 2000 ms, whereas the researchers who found the late disengagement effect using the dot probe and visual cueing tasks did not test the attention allocation in such long stimuli exposure times. Therefore, Calvo and Avero contended that their results with the ones of the former researchers were compatible, and in none of the results in the interval between 500 ms and 2000 ms a significant difference in engagement was found.

It is not only RT, or single eye movement indices (such as how fast a stimulus is fixated, or how long the fixations last) data that are of interest when investigating attention deployment. The visual scanpaths patterns that are concluded from a combination of visual attention indices are also important. Hypervigilant-avoidance is one of these patterns which is indexed, for instance, by a fast first fixation on a stimulus, in combination with a short dwell time, and few fixations on the stimulus. This pattern has been found in a number of eye-tracked visual search studies using facial stimuli. For instance, in Rohner's (2002) study, high and low trait anxious participants were shown pairs of angry-neutral, or happy-neutral faces, after they classified an asterisk or a circle in the centre of the screen (this classification task before the appearance of the emotional stimuli was to make sure that the participants are attending the screen). Both high and low anxious groups initially directed their gaze more often toward the angry faces than to the happy faces, therefore showed vigilance for the threat related faces in the beginning of their course of attention (i.e., below 1000ms). The researcher argued that such an attentional bias effect toward angry faces independent of participant's anxiety was in line with Mogg and Bradley's (e.g., Mogg & Bradley, 1998) cognitive-motivational model, based on which, people regardless of their anxiety level attend to the stimuli that they perceive as threatening. At the end of the stimuli display time (i.e., between 2000-3000ms), however, only high trait anxious individuals averted their gaze from angry faces and showed avoidance of the threat-related stimuli. These results indicate a hypervigilance-avoidance pattern in the anxious participants, which has also been found in the eye-tracked visual search studies of spider phobics (see the discussions later in this section).

Hyperscanning is the other visual scanpaths pattern that is indexed, for instance, by increased number of fixations and scanpaths length. This pattern has been reported in

Horley et al. (2004) and Green, Williams, and Davidson's (2003) studies. In Horley et al.'s study, social phobic and healthy control participants were instructed to freely look at colour photographs of happy, neutral, sad, and angry facial emotions, which were posed by the same model, and were shown in fixed order in the centre of the screen successively. The eye movement data showed a pattern of hyperscanning in social phobic participants, reflected in increased scanpaths length when attending to the facial stimuli, specially angry faces, which was not found in the healthy participants. The social phobic group also showed a tendency to avoid fixating on the eye regions of the faces; that is, their fixations on the eye regions decreased across the facial stimuli, particularly for anger expressions. The healthy group, on the other hand, showed a significant increase in their fixations from the beginning to the end of the stimuli presentation. In Green, Williams and Davidson's study, colour photographs of threat (anger, fear) and non-threat (sad, happy, neutral) facial expressions were used as the search task stimuli, and the healthy adult participants showed extended scanning (i.e., longer and more fixations) on feature areas of threat related expressions. Based on the findings, the researchers proposed the existence of a common vigilant style of scanning of threat related faces in the general population.

In a more recent study by Derakshan and Koster (2010), healthy adult participants completed an odd-one-out search task in which 3 dimensional schematic angry, happy and neutral faces were used as the task's stimuli, and both RTs and eye movements were recorded. In each trial of the task 8 faces were presented in a circular stimulus array, with 7 filler faces that were identical and a target face that belonged to a different emotional face type. (e.g., an angry face among 7 neutral faces). The participants' manual RTs were slowest when detecting an angry target among happy fillers (crowd in the researchers' term), and a happy target among angry fillers. Anxiety significantly interacted with this effect, so that high anxiety group were significantly slower than low anxiety group in these conditions' targets detection. The eye movement data in this research also showed that participants made more fixations, and dwelled for longer times, on the fillers before fixating the target when the fillers were emotional (happy and angry) than neutral faces. This effect was displayed by both anxious and non-anxious individuals, and anxiety did not interact with the effect. Another index reported by the researchers was the number of filler faces fixated (i.e., how many faces fixated, rather than how many fixations made) before fixating the target face. With regard to this index, it was found that the number of emotional faces fixated were significantly higher

than neutral faces, which was interpreted as a vigilant style of searching in emotional faces [which seems similar to hyper-scanning pattern]. Again anxiety did not interact significantly with this effect. The RT and eye movement data were also analysed to examine the processing course after the target was fixated until the manual response was made. In this regard, the time elapsed after the target fixation and before the manual RT was longer in the conditions where both the target and fillers were emotional faces than the conditions where either the target or the fillers were neutral faces. This effect was interpreted as indexing the target processing time. Anxiety significantly interacted with this effect, so that the high anxious individuals were slower than the low anxious ones in processing the targets where both the target and fillers were emotional faces. Moreover, high anxious relative to low anxious participants fixated for longer times on the emotional target faces comparing with the neutral target faces, and more often continued fixating on the fillers after their first fixation on the target, in the conditions where both the target and fillers were emotional faces. Based on these findings, the researchers suggested that anxiety did not facilitate attention to threat stimuli, and nor did it delay disengagement from the stimuli. They argued that, in line with Eysenck's theory of attentional control (Eysenck, M. W., Derakhshan, N., Santos, R., & Calvo, M. G., 2007; as cited in Derakhshan & Koster, 2010), anxiety disrupted responding to emotional (angry and happy) facial targets when the targets are presented amongst other discrepant emotional faces. They, moreover, emphasised on the usefulness of collecting and analysing both RT and eye movement data to disentangle the underlying attentional mechanisms.

While all the above mentioned studies have employed adult samples, there have been few studies in which child samples were used to investigate attentional biases to threat related facial expressions using visual search paradigm, and most of them have been done recently. In the first study of this kind, Hadwin et al. (2003) tested samples of 6 to 8 years children from the general population in two experiments using the target search variant of the visual search tasks. In their first experiment they used schematic faces, and in the second experiment cartoon like faces, displaying anger, happiness, and neutral emotions. In both experiments, each of the three emotion expressions was presented in a separate block, and half the trials of each block were target present, and the other half target absent. In the target present trials, a target face was displayed amongst fillers (distractors in Hadwin et al.'s term) that were mixed up faces made of the features of the same emotion expression, and all the stimuli in the stimulus arrays of

the target absent trials were mixed up faces of the same emotion expression. The children's task was to respond by pressing buttons on a key pad whether the block's target was present in the stimulus array or not. The experiment consisted of three set sizes of 4, 6, and 8, to examine whether the participants followed a parallel (preattentive) or a serial (attentive) search strategy (see section 1.3.4.1 for a discussion about serial versus parallel search strategies). It was found in the first experiment that all children detected angry faces amongst their fillers faster than neutral or sad faces amongst their fillers, however the children's anxiety scores were not associated with faster detection of angry faces in any of the experiments. Therefore the results suggested a general threatening face bias. A specific effect of anxiety on search task results was found in the first experiment's findings, based on which high anxiety scores were associated with shorter times needed to decide whether an angry face was absent in the stimulus array. This effect was not found in the second experiment. Moreover, evidence was found in both experiments' results in support of a self-terminating serial search strategy when searching for schematic faces, which means that angry faces did not pop out of the distractors arrays.

Although, in Hadwin et al's study, anxious children did not detect anger emotional expression any faster than other emotional expressions, a general negativity attentional bias effect (i.e., attentional bias towards both angry and sad faces) in anxious children was found in a recent study. Waters and Lipp (2008) found both faster detection of, and distraction by, angry faces in an odd-one-out task using schematic facial stimuli in children aged 8-11 years. In Experiment 1 of this study, there were four types of stimuli: an angry face displayed amongst neutral faces, a neutral face displayed amongst angry faces, all neutral faces, and all angry faces; and the stimuli were presented in set sizes of 4 and 9. Angry faces amongst neutral faces were detected faster than vice versa by all children, which, according to the researchers, can be interpreted as the angry faces both capture and hold attention. Deciding whether all the stimuli were of the same type also took longer when the stimuli were all angry faces, which was interpreted as angry faces needing more time to process, and therefore, holding attention. In Experiment 2, an angry, a sad, or a happy face was presented amongst 8 neutral faces in an odd-one-out task, in which half the trials were target present and in the other half all 9 stimuli were neutral faces. Consistent with the threat superiority proposal (e.g., Öhman & Mineka, 2001) both anxious and non-anxious children were faster to detect angry deviant faces, relative to sad and happy deviant faces, in the background of neutral faces. Moreover,

the detection of both angry and sad deviant faces was faster than deviant happy faces in high anxious children.

The effect of fast detection of angry faces in the visual search paradigm, was repeated by LoBue (2009) in 5 experiments using 5-year-old children and adult participants. In the first 4 experiments of this study, colour photographs of happy, fearful, sad, and angry emotions in different combinations (one combination in each experiment) were used, and in the last experiment, schematic faces of angry, sad, happy, and neutral facial expressions were used so that one emotional face was presented with the neutral faces as the control stimuli. The findings showed that both young children and adults detected angry, fearful, and sad faces faster than happy faces, using both colour photographs of human faces, and line-drawn schematic faces. These findings support a general negativity bias. The angry and fearful faces were also detected faster than sad faces, but there was not any significant difference between the reaction times to angry faces and to fearful faces. These findings indicate a bias towards threat stimuli in general.

There are two eye-tracked visual search studies in which child participants were employed. In the study by Gamble and Rapee (2009), healthy and anxious children (7-11 years) and adolescents (12-17 years) were shown photographs of negative, happy and neutral facial expressions (in pairs of happy-neutral and negative-neutral expressions) for 500 and 3000 ms, and were instructed to view the photographs in any way they want. The researchers found that all participants, regardless of their anxiety level, showed a vigilance-avoidance attentional pattern when the stimuli were presented for 3000 ms. However, when the stimuli were presented for 500 ms, a difference between high and low anxiety groups appeared, so that anxious children directed their attention away from happy faces (in terms of eye movement index, it was less probable that their first fixations landed on happy faces), and anxious adolescents directed their first fixation away from negative faces. Based on these results, Gamble and Rapee argued that children and adults might have different attentional patterns when encountering emotional scenes.

The last study of this part has a similar design to other visual search tasks, but used an unusual sample. Peltola, Leppänen, Vogel-Farley, Hietanen, and Nelson (2009) found threat related attentional bias in 7-month-old infants using the eye-tracking methodology. They showed colour photographs of female models displaying happy, fearful, neutral and neutral with fearful eyes to the infants, and found that they spent

more time looking at the eyes region of the photographs. More importantly, it was shown that the infants took significantly longer time to disengage their attention from fearful faces as compared to happy and neutral faces, and that this effect was not found for the neutral faces with fearful eyes. Therefore they concluded that this effect cannot be attributed to only a single feature in fearful faces, i.e., to the wide open eyes in the faces.

1.3.3.1. Interim: Relevance to the thesis

In the first experiment of this thesis, children's attentional bias to threat and non-threat facial expressions was investigated. Hadwin et al.'s (2003) study was replicated in this study with the exception that the eye movement data were also recorded. At the time of conducting this study, no eye-tracking study had been done on threat related attentional biases in children. This experiment was carried out to investigate the eye movement patterns related to naturally occurring attentional biases, relative to newly acquired biases, in children. The attentional bias towards angry facial expressions depicted by schematic faces was considered as a good example of a naturally occurring threat related attentional bias. Thus, the results of this experiment was expected to provide us with the baseline visual attention allocation patterns which could be used as the comparison basis when interpreting the patterns related to the induced attentional biases toward newly feared stimuli in the next experiments.

Moreover, a sample size larger than the original study, almost twice the original sample size, was employed in this study to enhance the statistical power and maximise the probability of finding the possible magnified attentional bias effect in anxious children, which was not found in Hadwin et al.'s study. This was particularly important as both studies were conducted using samples from the general population. Employing larger samples can lead to a larger variance in anxiety scores, therefore enhancing the power of the statistical tests. Although, a few eye-tracked visual search studies on threat related biases using child samples have been conducted recently, the experiment that is reported in the next chapter of this thesis is still the only study of this type in which schematic facial stimuli have been used. A discussion on the probable advantages and disadvantages of using this type of stimuli in attentional bias studies is presented in the following.

1.3.4. The debates on the visual search for emotional faces

1.3.4.1. Parallel search or serial search

The first main debate is whether the visual search for angry faces is based on a parallel search mechanism in which angry faces pop out from other facial stimuli, or it is based on a serial search strategy in which an attentive search is needed to detect angry facial expressions (see, e.g., Treisman & Gelade, 1980; and Treisman & Gormican, 1988, for more explanation on parallel and serial search strategies). The results of a study by Hansen and Hansen (1988), support a parallel search mechanism when detecting angry faces in stimulus arrays in odd-one-out search tasks. In visual search studies, such as Hansen and Hansen's study, RTs to detect a target in different set sizes are compared to examine whether the mechanism of the search is parallel or serial. If increasing set sizes results in increasing RTs, it is concluded that the search is serial, because by having more fillers in the stimulus array, more time is needed to detect the target, which indicates that the fillers are processed serially before the target is detected. However, when increasing set sizes (e.g., from set size 4 to set size 9) does not significantly increase the time needed to detect the target, it is concluded that the search is parallel and the target pops out of the filler stimuli, that is, the fillers are not processed serially before detecting the target. In Hansen and Hansen's study, the RTs to find an angry face presented amongst 7 happy faces was not significantly different from the RTs to find an angry face presented amongst 2 happy faces. This was not the case for happy face targets presented amongst angry faces, as the RTs to find happy faces were significantly slower for the larger set size (set size 8) as compared to the smaller set size (set size 3). These results suggest that, in this study, the angry faces popped out of the happy faces as in a preattentive parallel search, but the mechanism of the search for happy faces amongst angry faces was serial. Other studies, however, do not support these findings. For instance, Purcell, Stewart and Skov (1996) re-examined the claim made by Hansen and Hansen (1988) by using the same human facial stimuli as employed by these researchers, once without applying the alterations that were made by them on the face photographs, and once with the alterations. They concluded that these alterations, and not the threat relatedness, have resulted in the angry faces to pop out from happy face background images as in a preattentive search type. By using the unaltered original gray-scale photographs, they even found that happy faces were detected faster among angry faces than vice versa. In Hadwin et al.'s (2003) study, the

debate on the parallel or serial search mechanisms was also examined by testing the effect of varying the stimulus arrays set sizes on participants RTs, and it was confirmed that a serial search strategy was followed when searching in the stimulus arrays.

1.3.4.2. Photographic or schematic faces

The other main debate is about the use of photographic or schematic faces as the search tasks stimuli. Some researchers (Calvo et al., 2008) suggested using real face photographs because of their ecological validity and generalizability to real life situations. However, some researchers (e.g., Juth et al., 2005) have supported using schematic faces and have contended that such stimuli bypass the interpersonal noise caused by the photographs. In the study by Juth and her colleagues, both photographs and schematic emotional faces in five experiments. In the first, second and third experiments, photographs of human faces were used, and attentional bias effects for happy faces were found. The researchers argued that such findings are similar to other studies in which this kind of stimuli has been used (e.g., Byrne & Eysenck, 1995). In their last experiment, they used schematic faces, and found an attentional bias towards angry face, which was stronger in highly anxious individuals. The researchers argued that schematic faces are advantageous to real photographs in tapping the anxiety-related attentional bias, because photographs can be affected by inevitable interpersonal noises, and therefore confound the emotion related attentional biases. Schematic faces, on the other hand, can bypass the noises and can be detected more efficiently because they match with the basic cognitive template of the emotion. They also pointed out that the studies that have found the attentional bias to angry faces using human faces photographs (e.g., Gilboa-Schechtman, Foa, & Amir, 1999) have used few individuals' photos in the search task overall, and a single person's photos in each stimulus array. Therefore, in these studies, the interpersonal noise was minimised, and an important requirement of the composition of the search tasks' stimuli, that is, the distractors' similarity was met. This is the other reason that they argued in favour of schematic facial stimuli: because a high rate of similarity between the targets and distractors can be warranted by employing these stimuli.

1.3.5. Visual search for fear-relevant stimuli

Several studies have employed the visual search method to investigate attentional biases towards snakes and spiders, which have been proposed to be feared by humans due to evolutionary reasons. Most of the studies, both in adults and children, with many of them using the eye tracking methodology, have supported the existence of attentional bias towards the animals. Such effects have been indexed by faster detection of the animals' images, distraction caused by the presence of the images, and visual attentional scanpaths when searching in the visual scenes that contained these threat relevant stimuli. These effects have been shown to be stronger in the individuals who were specifically fearful of these animals. There are, however, some debates about the attentional bias effects found in these studies, such as some methodological issues regarding the search tasks, and whether the attentional bias found is addressing an evolutionary root. The most relevant research and the debates will be discussed in this section.

Faster detection of fear-relevant animals has been found in a number of studies. For instance, Öhman, Flykt, and Steves's (2001) tested participants from non-clinical populations (students) in three experiments. The participants were not screened for the first and second experiments, but for the third experiment, a group of spider fearful and a group of snake fearful participants were screened to be compared against a non-fearful control group. They used colour slides of snake, spiders, flowers and mushrooms in matrices of 9 grid positions (Experiment 1) and 4 and 9 grid positions (Experiment 2 and 3), in odd-one-out search tasks. As mentioned before, in this type of search tasks, participants are asked to decide whether there is an image belonging to a different stimulus category in the stimulus array presented, or all the images in the array are from the same category of stimuli. Thus, the task was to identify a fear-relevant target (snake or spider) amongst non-feared distractors (flowers or mushrooms), or the non-feared target amongst the fear-relevant distractors. The results of all the experiments showed that all groups of participants detected snake and spider targets faster than mushroom and flower targets. The fearful participants were even faster to detect their own fear stimuli as compared to the other fear-relevant target, and were not faster than the control group to detect the fear-relevant target that was not their own fear object. Thus, for example, spider fearful individuals detected spiders faster than snakes and were faster than the control group to detect spiders, but detected snakes in a similar time as the

control group did. Moreover, based on the results of Experiments 2 and 3, where different set sizes were used, they concluded that phylogenetically fear-relevant images pop out from the surrounding as in a parallel, pre-attentive search.

As another example of the studies which have found the faster threat detection effect, in a study by Soares Esteves, Lundqvist, and Öhman (2009), three groups of participants, that is, fearful of spiders, fearful of snakes, and with little fear of snakes or spiders completed an odd-one-out search task. In this task, colour photographs of stimuli, consisting of spiders, snakes, mushrooms and fruits were presented in circular arrays, in which fruits were the filler stimuli and the other three stimuli were the targets. Each stimulus array contained one target and the rest of stimuli were fillers (fruits). The results showed that all participants detected the fear-relevant targets faster than mushrooms. More interestingly, when detecting the fear object, the specific fear object priority was found only for spider fearful participants; therefore participants fearful of snakes did not detect snakes any faster than spiders in this study. The parallel search debate was examined in another study by Lipp (2006), and unlike Öhman, Flykt, et al.'s (2001) findings, the search was found to be of a serial type. The threat related target detection times when it was displayed in 9 grid matrices, attenuated as compared to when it was displayed in 4 grid matrices, and this attenuation well exceeded the level expected for a parallel search type.

Only the interference effect of the fear-relevant stimuli, but not the faster detection of these stimuli, has been found in some other studies. For instance, in a study by Miltner, Krieschel, Hecht, Trippe, and Weiss (2004), similar stimuli as used by Öhman et al. (2001) were used to compare the speed of detecting a spider in spider phobic and non-phobic individuals. In all the experiments of this study, matrices of 16 grid location were used, and in the first two experiments, the instruction was to find a target (either a spider or a mushroom) in a matrix of flower images. In half of these trials a distractor of a different type was displayed in one of the grid positions, so that, when the target was a mushroom, a spider image distractor was displayed in one of the grid positions, and vice versa, to examine whether a spider distractor would capture participants' attention and delay their response when searching for the target. The non-phobic participants detected the fear irrelevant target faster than the fear-relevant one, and although the phobic participants were faster than the non-phobics in detecting the fear-relevant target, they needed almost the same time to detect the fear-relevant and fear irrelevant targets. The presence of the fear-relevant distractor, however, delayed the detection of the fear-

irrelevant target in the phobic participants (but not in the non-phobics). This effect was supported by eye movement data, as they showed that in the matrices where a spider distractor was displayed, spider phobics more than the non-phobics fixated the spider distractor grid location before fixating the target grid location. In the third experiment, Miltner et al. conducted an odd-one-out search in which either a mushroom or a spider was displayed among 15 flowers (target present), or all images were flowers (target absent). In this task also no speeded detection of spider images was found in spider-phobics relative to the non-phobics, and relative to the mushroom image.

The interference effect of spider images in spider fearful individuals was repeated in a visual search study by Rinck, Reinecke, Ellwart, Heuer, and Becker (2005) in all three types of search tasks that were employed. These were the odd-one-out search, the target search, and the category search tasks, in all of which matrices of 20 grid locations consisted of spider and fear irrelevant animals' images, including butterflies, beetles, and dragonflies were used. In the target search task, the image of each trial's target appeared on the screen before displaying the stimulus array of the trial, and the participants were instructed to search for that pre-displayed image in the arrays, and in the category search task, the participants were instructed to search for a specific category of animal, e.g. butterfly, in the arrays. The fast target detection effect was found only in the odd-one-out and in the category search tasks, but not in the target search task. The reaction time data were consistent with eye movement data, and in the odd-one-out task, for instance, the gaze fixation durations of the spider fearful participants, as compared to non-fearful participants, was longer on spider grid positions when spiders were distractors in the stimuli matrices, and their gaze fixation durations on distractors were shorter when a spider was the target.

An interference effect which was reflected in retarded manual RTs was found also by Lipp and Waters (2007) and by Lipp (2006, Experiment 2) for both snake and spider stimuli in non-phobic samples. In Lipp and Waters' study, single distractor images were displayed in the trials' stimulus arrays, and in Lipp's study an odd-one-out search task was used. It was found in Lipp and Water's study that the interference effect of spider images was more salient for the spider anxious, and the interference effect of snake images was more salient for the snake anxious participants. The preferential processing effect for the specific fear object in fearful populations was also found in Soares, Esteves, Lundqvist and Öhman (2009) and in Soares, Esteves and Flykt (2009, Experiment 2). In the first study, the preferential bias effect was found only in spider

fearfuls, but not for snake fearfuls. In this study, the fear-relevant targets were compared with mushroom images as control targets presented in a background of fruit images. In the second study, unlike the previous study, non-fearful participants did not display any attentional bias towards fear-relevant stimuli which were not feared by them. In this study, an odd-one-out search task was used and the fear-relevant stimuli were compared with fear irrelevant animals' images (cats and fish) (see below for a discussion on the effect of the images used in the stimulus arrays on the search tasks' results).

Two visual scanpaths patterns, hypervigilant-avoidance, and hyperscanning were reported in the studies using emotional facial expressions as the search tasks stimuli. The hypervigilance-avoidance pattern, in addition to a general avoidance pattern (without vigilance), have also been reported in spider phobics in the eye-tracked visual search studies. For instance, Rinck and Becker (2006), used matrices with four grid locations containing spiders, butterflies, cats, and dogs in a search task with a free-view instruction, and found that it was more probable that the spider fearfuls, relative to non-fearfuls, fixate first the spider's grid location. The spider fearfuls then turned their attention away from the images, and avoided the images in the rest of 1 minute matrix display time, which resulted in the spider fearfuls' total gaze duration times on spider images being shorter than the non-fearful participants. The results of two more studies, Hermans, Vansteenwegen, and Eelen (1999), and Pflugshaupt et al. (2005) indicated similar effect. In Hermans et al.'s study, spider fearful and non-fearful participants were shown large images of spiders paired with pictures of flowers and were instructed to freely view the images (under a cover story which concealed the experimenters aims of the study) while their eye movements were recorded. They found that spider anxious group looked significantly more at the spider images in the beginning of the stimuli presentation times, but with the progression of time, they increasingly looked away from the spiders and looked at the flower images. The non-fearfuls also looked more at the spiders in the first 500ms, but their looking pattern remained stable over time. In Pflugshaupt et al.'s study spider images (1 to 3 images) were added to large pictures of everyday scenes (such as a sitting room) and spider phobic and non-phobic participants were instructed to search the scene for the spiders, count them and specify their numbers in each scene. The results of this study showed that spider phobics, as compared to the non-phobics, detected the spiders faster, fixated more closely on the

spider images in the early stages of searching the scenes, then fixated further away from these images in the later stages of their explorations.

Pflugshaupt et al. (2007) conducted a similar search task to the one used in Hermans et al., but found different scanpaths patterns. In the visual exploration task of this study, spider phobic and non-phobic participants were shown large close-up images of spiders paired with an image of another animal (a butterfly, a fly, a snake, a crab, a toad, and a lizard) for 9 seconds, with a free view instruction. At the top and bottom of the screen some blank margins were included to give participants other options in case they did not want to look at the animals' images. Unlike the studies mentioned above no vigilance effect was found, but similar to these studies, the phobic participants increasingly avoided the spider images over time.

Although, the eye movement studies reviewed in this part showed that phobic individuals increasingly avoid spider images after the first orientation; such an avoidance response might only be limited to the pictures presented on the screen and might not be the case for the real life encounters. This has been suggested by Rinck, Kwakkenbos, Dotsch, Wigboldus, and Becker (2010) in a recent study in which a virtual interactive search task more similar to the real life experiences was employed. The spider anxious and non-anxious individuals of this study wore a stereoscopic head mounted display device, that is, a helmet-like apparatus which covered 60 of their visual field, and through which scenes of a virtual art museum were displayed. The task was to find the museum's items production year, and the participants were able to walk around the lab to do the task. During the task, stationary and moving spiders, as well as spots similar to spiders appeared on the virtual museum walls, and participants' attentional and behavioural reactions to the stimuli were recorded. The results showed that spider fearfuls behaviourally avoided the virtual spiders and the similar stimuli, more than non-fearful participants, and more interestingly, not only they did not turn their attention away from spiders later, they spent more time than the non-fearful participants looking at the spider stimuli and kept the spider stimuli in their view fields more so than the non-fearfuls. These results suggest that the visual attentional patterns when encountering real spiders in the environment might be different from seeing spider images on the screen, and that the spider phobics might prefer monitoring the creatures if they are in a nearby place and there is a real risk involved, rather than looking away. Such a conclusion can be supported by the findings of Lange, Tierney, Reinhardt-Rutland and Vivekanada-Schmidt (2004) who recorded spider phobics' and non-

phobics' eye movements when they were watching a moderately interesting videotape on a TV screen. At the same time, a real spider (a tarantula) was presented in the visual field of the participants in a transparent plastic container with firmly closed lid. The spider phobic participants viewed the video less, and the live spider and exit door more, than the non-phobics.

To our knowledge, only two visual search studies have been done on child samples in this area of research, both of which conducted by LoBue and DeLoache who found that preschool and infants displayed visual attentional prioritisation of snakes. In their first study (LoBue & DeLoache, 2008), they showed that both preschool children and adults detected snakes more quickly amongst flowers, frogs, and caterpillars than vice versa using the odd-one-out task. It was also found that there is no difference in detecting a frog amongst flowers versus a flower amongst frogs, neither in children nor in adults. In their next study, LoBue and DeLoache (2009) examined visual attention to fear-relevant and non-fear-relevant images in 8-14 months infants. In this study, each infant was seated on a parent's lap in front of a white screen, and images of snakes, flowers, and frogs (the same images as used in the previous study) were displayed on the screen in pairs. A video camera recorded the orientation of the infants' sights on the screen, and a coder, who was blind to the images shown in each trial, used the videotapes to code the infants' first look, the latency of their first look, and the time of their looking for each pair of images. Their results showed that the infants looked at the direction of snakes' images significantly quicker than the flowers images, however, unlike adults and preschool children in the previous study, they did not show an attentional priority towards snakes as compared to frogs. No significant difference was found between threat and non-threat stimuli in terms of the first look and the time of looking indices.

1.3.5.1. The debate about the employed images in stimulus arrays

Several visual search studies with the aim of examining the attentional bias towards snakes and spiders have used pictures of flowers and mushrooms as the comparison images in their stimulus arrays. The use of these stimuli has been questioned by Lipp and his colleagues, who concluded from their research that the attentional bias effect to snakes and spiders might simply be due to the use of these comparison images. Lipp, Derakshan, Waters, and Logies (2004) used both images of pleasant animals (horses and cats) and fear-relevant animals (snakes and spiders) in matrices made of pictures of

flowers and mushrooms and found that both images of pleasant animals and fear-relevant animals are detected faster amongst mushrooms and flowers than vice versa, and the detection speed of fear-relevant animals was not different from fear irrelevant animals. Similar results were found by Lipp (2006, Experiment 1) when employing pictures of predator animals (big cats, wolves) and fear irrelevant animals (cats, horses) amongst flowers and mushrooms and vice versa. Moreover, Soares, Esteves, and Flykt (2009) showed that when both the targets and the comparison images in the stimulus arrays were from animals category, non-clinical participants did not show any attentional bias towards fear-relevant animals. They used pictures of harmless animals (cats and fish), with pictures of fear-relevant animals (spiders and snakes) in different array combinations, and found that spiders and snakes were detected no quicker than cats and fish. It was argued by Lipp et al., and by Soares, Esteves and Flykt that among the background of mushrooms and flowers, pictures of all animals are found faster, and the attentional selectivity advantage which has been found for the pictures of snakes and spiders does not reflect on fear relevance, but on the homogeneity and visual specifications of the background-deviant pictures. However, as seen before (e.g., Rinck, et al., 2005), attentional bias toward snakes and spiders have been displayed using different background images including animal images, therefore, the effects might be fairly independent of the background images.

1.3.5.2. The debate about phylogenetic fear versus ontogenetic fear

The hypotheses that fear of snakes and spiders has an evolutionary basis, and that this phylogenetic fear-relevance is the reason for the attentional biases have also been debated. Research has shown that the attentional bias effects found in the visual search tasks are not specific to these animals, and occur for more modern fear cues such as guns, and syringes as well. For instance, Blanchette (2006) using samples from the general population and odd-one-out search tasks found that detection of ontogenetically fear-relevant stimuli such as guns, knives and syringes, amongst clocks, toasters, and pens was as rapid and efficient as detecting the evolutionary fear-relevant animals among flowers, mushrooms, and rabbits (and in some occasions detecting the ontologically fear-relevant objects were even more efficient than detecting the animals). These findings were supported later by Fox, Griggs, and Mouchlianitis (2007) who found that non-clinical participants show attentional bias towards snakes and guns displayed amongst flowers, mushrooms, toasters, and electrical kettles in the odd-one-

out search tasks, and that detecting the snakes was not faster than detecting guns. This argument is interesting and more research using different attentional bias tasks needs to be conducted to reach a certain conclusion about the debate.

1.4. Conclusion

Receiving threat information can lead to the acquisition of fear. In a single experimental session, after receiving threat information, children show all three fear responses in Lang's model (i.e., physiological, behavioural, and cognitive) to stimuli about which they have no prior experience. Interestingly, they also exhibit visual attentional bias toward the newly feared stimulus, which implies that the cognitive system adapts itself promptly with new inputs, and the new sources of threats that are defined by the new inputs are rapidly prioritised at attentional level. This attentional bias effect was found in two dot probe studies (Field, 2006c, 2006a). The dot probe paradigm, however, has been criticised for having several shortcomings. For instance, this paradigm measures attentional deployment in discrete time points, and cannot provide a continuous measure of the entire course of attention deployment. In other words, it only captures the attentional biases that occur at the end of the prime display times. More importantly the paradigm has been found to be an unreliable measure of threat related attentional biases.

It has been suggested that the eye-tracked visual search method is not affected by such shortfalls, and is the most effective way of examining selective attention (e.g., In-Albon & Schneider, 2010). Re-examining the findings (i.e., the attentional bias effect toward novel animals that is acquired by receiving threat information) by employing this method, therefore, can yield more reliable and detailed information about the possible biases. In two studies of this thesis, this method was employed to explore the attention deployment patterns related to the newly acquired biases. Contrasting these patterns with the ones of naturally occurring (pre-established) threat related biases, such as attentional bias to threat related facial stimuli, can inform us about the possible similarities and differences between the two types of biases. Therefore, a visual search study, in which schematic facial stimuli had been used, was replicated to establish a comparison basis against which the attention deployment patterns associated with the induced biases can be compared.

The two main categories of threat relevant stimuli in the attentional bias studies are threatening facial expressions and fear-relevant animals. Both types of stimuli are assumed to be related to phylogenetic fears, and numerous research studies have demonstrated that these stimuli are prioritised over fear-irrelevant stimuli in visual attention. In the same way that it is possible to induce attentional bias of novel stimuli by threat information, it can be possible to increase the attentional biases to fear-relevant animals. Vicarious learning has been found to induce (or increase) fear of fear-relevant stimuli (snake and spider toys) in toddlers (Gerull & Rapee, 2002; Dubi, et al., 2008). Thus, it can be predicted that information, as the other indirect pathway to fear learning, can also induce or increase fear of, and attentional bias toward, fear-relevant animals. In the last two studies of this thesis, using three different variants of the eye-tracked visual search task, it is examined whether receiving threat information about a snake species can enhance the attentional bias effect towards it.

Chapter 2: Attentional bias toward Threatening Facial Expressions in Children

2.1. Introduction

Angry facial expressions signal dangers arising from other humans (Öhman & Mineka, 2001). Although, humans depend on social life for survival, social life is also concomitant with some vulnerabilities. For instance, social disapproval can lead to descending in social hierarchies and consequent poorer life circumstances, and social disputes can escalate to even fatal outcomes (Öhman, 2000). Angry facial expressions can be a precursor of these threats, and therefore, humans have needed to attend to these expressions. It is argued that such an evolutionary pressure has led to establishing an attentional prioritisation of threatening facial expressions and such expressions particularly attract human's attention (Öhman & Mineka, 2001).

As reviewed in the previous chapter, such attentional prioritisation of angry facial expressions has been found in several studies using paradigms such as the visual cueing (e.g., Koster, Crombez, Verschuere, Van Damme, et al., 2006), dot probe (e.g., Mogg, Millar, et al., 2000) and visual search (e.g., Juth, et al., 2005). The attentional bias to threatening faces can be considered as a naturally occurring, or pre-established bias, in comparison with the attentional biases that are induced by means of experimental interventions.

Giving threat information, as an experimental intervention, has resulted in inducing threat related attentional biases in children. These bias effects have been measured in the previous research using the dot probe (Field, 2006a; 2006b), and visual search (Field, et al., 2009) paradigms. In the second and third experiments of this thesis, which are reported in the third chapter, threat related biases were induced in children by administering the intervention methods similar to the methods used by Field and his colleagues in the aforementioned studies. The induced biases were then examined using two variants of the visual search paradigms, alongside which the participants' eye movements were also recorded. As discussed before, this method of measuring threat related attentional biases, that is, the eye-tracked visual search tasks, can be the most reliable and informative measure of selective attention among the existing attentional

bias paradigms (e.g., In-Albon & Schneider, 2010). The aim of the experiments of Chapter 3, therefore, was to examine the attention deployment patterns associated with induced attentional biases.

When designing these experiments, it was considered useful to compare the overt attentional deployment patterns associated with the induced threat related attentional biases against the patterns associated with the naturally occurring biases. The aim of this comparison was to specify the characteristics of the overt attention deployment patterns related to the induced biases, and to examine the possible similarities and differences between the induced and naturally occurring biases in terms of the visual scanpath patterns. To this end, the scanpaths patterns related to naturally occurring threat related attentional biases (e.g., the biases to threatening facial expressions or to fear-relevant animals) in children were needed. However, at the time of designing the experiments, we did not find any published eye-tracking study in this area of research using child participants. It was, therefore, decided to carry out an eye-tracked visual search study on children using naturally occurring threat related stimuli.

To minimize the possibility of failing to find the predicted overt attention deployment patterns in this study, it was decided to replicate a visual search study that had already found attentional bias to threat stimuli in children. For this purpose, the first experiment of Hadwin et al.'s (2003) study was replicated. As reviewed in the previous chapter, in this experiment, children's RTs were significantly faster when detecting angry faces amongst their relevant filler stimuli (distractors in Hadwin et al.'s term) than happy and neutral faces amongst their relevant filler stimuli. The participants of this study were 7- to 10- year-old children. This age range is similar to the age range of the participants of the other child studies of this thesis (Chapter 3), and this is one of the reasons for replicating this study. Moreover, in Hadwin et al.'s study, the bias effect was specific to angry facial expression, and not a general emotional bias effect (c.f., Waters & Lipp, 2008). Another important reason for replicating this experiment was the stimuli used in the experiment, that is, line drawing schematic faces. Such stimuli have two main advantages over photographic stimuli: firstly, these stimuli are considered (e.g., Juth, et al., 2005) to tap threat related attentional biases more effectively than photographic facial stimuli. Secondly, satisfactory experimental control can be applied when creating target and control (filler) stimuli using line drawing faces, as both types of stimuli are created using the same facial features. In sum, these specifications, in our evaluation, made Hadwin et al.'s study a suitable option for replication.

Although a specific attentional bias to threatening facial expressions was found in Hadwin et al.'s experiment, the findings of other research (using mainly adult samples) in this area are mixed. Some studies reported a general attentional bias to emotional faces including happy and angry facial expressions. For instance, an interference effect of emotional faces was found in Cooper, Hungr, & Kingstone's (2007) study in which both happy and angry facial stimuli delayed the first fixations on irrelevant targets. Moreover, in Nummenmaa, Hyönä and Calvo's (2006) study, emotional scenes (in general, and not only threat related scenes) were fixated more often, and it was more probable that the first fixations landed on these scenes, as compared to neutral images, despite the instructions to ignore the emotional pictures. Similarly, in a more recent study, Derakhshan and Koster (2010) used 3 dimensional schematic faces in an odd-one-out search task. An interference effect was caused by emotional (happy and angry) faces, which was indexed by delays in manual RTs when detecting the deviant image in the stimulus arrays. This effect interacted with the participants' anxiety levels, based on which, highly anxious participants were significantly slower to respond to a happy face target amongst angry faces, and an angry face target amongst happy faces (i.e., when both target and fillers were emotional faces), than the low anxiety participants. Moreover, a general attentional bias effect for both high and low anxiety participants was found in the eye movement data indicating longer dwell times and more fixations on fillers in the conditions where both the target and fillers were emotional. In these conditions, a vigilant style of scanning was also found, indexed by fixating more faces before making the manual response to the target, and again the effect was observed for both high and low anxiety participants. It was discussed that anxiety is associated with neither an early engagement in, nor a late disengagement from, angry faces, but with disruption in responding to emotional targets when the visual context contains emotional information.

There are also visual search task studies using emotional facial stimuli in which no attentional bias to threatening faces has been found. For example, in Calvo, Nummenmaa and Avero's (2008) study, participants' RTs and first fixation times were faster when detecting happy, surprised and disgusted faces among neutral faces, as compared to detecting sad, fearful, and angry faces among neutral faces; and in Gamble and Rapee's (2009) study anxious adolescents directed their first fixation away from negative faces (including threatening faces) when the faces were presented for 500ms.

Visual scanpaths patterns such as hypervigilance-avoidance have also been found in the eye-tracked visual search studies using emotional stimuli. The results are again mixed as in some studies this pattern was specific to threatening faces, and in other studies this was not the case. For instance, in Calvo and Avero's (2005) study, an early attentional engagement with both harm-related and positive emotional pictures and a late avoidance of harm related pictures were found in high trait anxious individuals. These effects, however, were not found for threat related pictures. High anxious individuals were also more likely than the low anxious ones to fixate first on emotional pictures (not only threat related pictures). Rohner's (2002) results are more consistent with threat prioritisation predictions. He found that both anxious and non-anxious individuals showed vigilance for threat related faces in the beginning of their search (below 1000ms), but high anxious individuals averted their gaze away from angry faces at the end of the time course of attention (between 2000 and 3000ms). Similar patterns were found in a more recent study by Gamble and Rapee (2009) in both anxious and non-anxious children and adolescents to threatening facial expressions when the stimuli were presented for 3000ms. It was also less likely that anxious children, comparing with non-anxious ones, fixate first on happy faces in the pair of pictures presented in each trial.

It should be noted that in all three aforementioned studies that have found a hypervigilance-avoidance pattern to emotional and facial stimuli, the stimulus arrays consisted of pair of pictures, which is similar to the stimuli sets used in the dot probe task. Similarly, in some dot probe studies using emotional facial expressions as prime pictures, the hypervigilance-avoidance pattern has been inferred from RT data (e.g., Garner, et al., 2006b). A similar scanpaths pattern called hyperscanning-avoidance has also been reported by Horley, Gonsalvez, and Gordon (2004) using single photographic facial stimuli in social phobics. Horley et al. found that these individuals avoid fixating on feature areas in angry faces, and scan extensively non-feature areas.

Despite the inconsistent findings of the visual search studies using emotional facial expressions, as mentioned before, Hadwin et al.'s (2003) found an attentional bias effect specific to angry facial expressions. This was the main reason for replicating this experiment, and it was predicted that by replicating this study, a similar specific attentional bias towards threatening faces can be found. As mentioned before, the participating children's eye movements were also recorded to examine the overt attention deployment patterns associated with this type of naturally occurring attentional

bias. These scanpaths patterns were considered as the baseline patterns, against which the overt attention deployment patterns associated with induced biases were compared in the next chapters of this thesis.

Followed from Hadwin et al.'s findings, it was predicted that the RTs to detect angry facial expressions would be significantly faster than the RTs to detect happy and neutral expressions. The second prediction was that the participants' trait anxiety scores would have a significant negative relationship with their RTs to detect angry facial expressions, whereas there would not be such a relationship between trait anxiety scores and detecting happy and neutral faces. This second effect was not found in Hadwin et al.'s study, and as discussed in the previous chapter, this might have been because of using a small non-clinical sample, in which the variance of anxiety was too limited to show a significant effect. In the current study, a sample almost twice the size of the original study's sample was recruited and it was predicted that the relationship between trait anxiety and the detection of threat related targets would be found.

Due to the differences between the design and the stimuli used in the current study and previous studies, no specific prediction was made in terms of the overt attentional deployment (eye movement) results. As the third hypothesis, it was generally predicted that the eye movement data would show a type of attentional bias effect towards angry faces. This bias could, for instance, be an early engagement one (which has been reported by some previous studies, e.g., Bradley, et al., 1998), indexed by a quicker first fixation time on angry face targets than happy and neutral targets; or a delayed disengagement bias (which has been reported by some previous studies, e.g., Fox et al., 2001), indexed by a longer dwell time on angry faces than happy and neutral faces, while there would be no difference among the times of the first fixation on the faces. As the fourth hypothesis, it was predicted that trait anxiety scores would have a significant relationship with the overt attentional bias effects indexed by the eye movement measures.

2.2. Method

2.2.1. Participants

Recruitment of the child participants in the current experiment, and the other child studies of this thesis, was done in two steps. First, the researcher approached the

primary schools in and around Brighton by sending a letter to each school's head teacher. The letter (Appendix A) explained the research and the experimental tasks with an emphasis on the ethical considerations observed for the research. If the head teacher agreed with the school to accommodate the research, then the parental consent letters (Appendix A) were sent to the parents of all 6- to 11-year-old children at the school. The parents were asked to sign the consent form attached to the letter and return it to the school, if they were happy with the participation of their child in the study (opt in consent). No specific exclusion criteria were set for participating in the study. The children whose parents sent back the signed consent form were invited to the experiment venue and asked to participate in the study (the recruitment method of the other child studies of this thesis was similar to the method used in the current study). For the current experiment, 85 children were recruited from three primary schools in Brighton. From this sample, 84 participants completed the anxiety test. A female child participant, aged 6, had recently immigrated to the UK and had trouble understanding English, therefore, could not complete the anxiety test. From the participants who completed the anxiety test, 2 participants did not want to start the visual search task; the calibration of 3 participants' eye movements failed; 10 participants asked to stop the visual search task in different stages of the task; and the eye movement data of two participants were lost due to technical problems (the data transfer from the eye tracker to the host computer failed). The final sample consisted of 38 girls and 31 boys, aged between 6 and 11 years old ($M = 8.04$, $SD = 1.62$).

2.2.2. Materials

The anxiety test. For measuring trait anxiety, the Trait sub-scale of the State-Trait Anxiety Inventory for Children (STAI-C, Spielberger, 1973) was employed with Prof. Charles Spielberger's permission. The population that was employed by Spielberger to normalise the STAI-C consisted of fourth- to sixth- grade elementary school children (in U.S.) which is equivalent to the age range of 9 to 12 years. However, according to Papay and Spielberger (1986), the test can be administered on kindergarten through sixth-grade children, providing that it is administered individually on kindergarten and first-grade children. Therefore, considering that the participants of the present experiment were tested individually (see the procedure section below), the STAI-C is an appropriate test for the sample employed in the present experiment. The Trait sub-scale

of this test measures the anxiety related feelings in the long term, as opposed to the State sub-scale that measures anxiety signs at the time of the test (Appendix G). The reliability of the trait anxiety scale was measured in the current experiment sample and the resulting Cronbach's α was 0.74 indicating the scale's good internal consistency.

The visual search task. This was the same task as the task used in Experiment 1 of Hadwin et al.'s (2003) study, except that the participants' eye movements were also recorded in the current experiment. The search task consisted of 216 trials, divided into 3 blocks, with one block for each facial expression (happy, angry, and neutral). The stimulus arrays used in the task were presented in 3 set sizes (4, 6, and 8) with equal numbers of target present and target absent trials. In the target present trials, a line drawing face resembling a normal face (i.e., not a mixed up face) was presented amongst filler stimuli (which were mixed up faces), and in the target absent trials, all the stimuli in the array were filler stimuli. The filler stimuli were made by mixing up the target faces' features, therefore, both the target and filler stimuli in each condition were made of the same facial features. The facial stimuli were presented in circular arrays (Appendix I): 18 stimulus array types were used in the experiment, consisting of 2 target (present or absent) \times 3 set size (4, 6, or 8) \times 3 emotion expression types (happy, angry, or neutral).

2.2.3. Apparatus

The visual search task was run on a Toshiba Satellite Pro A120 laptop. The task was programmed by Dr. Samuel Hutton using the Experiment Builder software (SR-Research Ltd, Ontario), and eye movements were recorded with a portable Eye Link 1000 system (SR Research Ltd, Ontario). This system comprises an infrared emission device co-located with a desktop mounted digital camera, and a "lunch box" style computer which serves as the main eye movement data processor. The stimulus display is controlled by another computer (in this case the laptop) linked to a 17" TFT screen placed 60cm in front of the participants, whose head movements are minimised with a table mounted forehead/chin rest. The Eye Link system has a sampling rate of 1000Hz, and when properly calibrated has a spatial accuracy of less than 0.25 of a degree of visual angle. A monocular eye movement recording using the left eye was made for all participants in this experiment. All RT responses were made using the two "trigger"

keys of a USB gamepad one key for a positive response, “Yes” button, and one for a negative response, “No” button.

2.2.4. Procedure

Children were tested independently in a generally quiet place at their schools (including the library, health care, or play rooms which were not in use at the time of the experiment). Each child was given a brief explanation of the experiment and its procedure, what was expected of them, and their right to stop doing the test, or to have a break at any time during the experiment. In the experiment session, the participants first answered the anxiety test, then completed the visual search task. The young participating children (6- and 7- year olds) were asked whether they could read the instructions and items of the anxiety test, or they preferred that the experimenter read out the items for them. Only a few children asked the experimenter to read out the items. The participating children were also asked whether they could understand the instructions and items of the test well. If their answer was positive, it was assumed that their language comprehension was adequate for the purpose of this research. As mentioned before, except for one child, other participants stated that they understood the statements well and answered the anxiety test. For doing the search task, they were seated at another table, on which the monitor screen and digital camera were placed, on a chair, which suited their height, and were asked to put their head on the headrest, which was then adjusted. The eye tracker calibration began after the children felt comfortable in their chairs. The calibration was done by displaying black dots on nine different positions on the screen, and the participants were asked to follow the dots with their eyes while the camera was adjusted to capture their eye's corneal reflection. After the calibration, the visual search task was conducted. Before starting each block of the search task, the children were shown the target and filler faces on separate pieces of papers and were asked what the faces were. They generally mentioned the type of the facial expressions as expected (with the exception that few of them thought that the neutral face was a sad face), and named the scrambled non-faces as a “jumbled-up” face (few of them thought the scrambled face made up of the angry face’s features was a “piggy” face). They were then verbally instructed to search for the target face amongst the jumbled up faces (both shown on the pieces of papers before each block); and to press the right button on the controller if they found the target, and the left button if all

the faces were jumbled up faces. After giving the verbal instructions, they were asked to put their chin back on the chin rest, and the search task started. In the beginning of each block, an instructions page was displayed that re-iterated the verbal instructions. Both speed and accuracy was emphasised, with a special emphasis on accuracy. It was ensured that they fully understood the instructions before carrying out the search tasks. The blocks were presented in a counter-balanced order, so that approximately equal numbers of participants received each one of the block presentation orders. Also within each block, trial presentation (i.e., target presence \times set size) was randomised. Between the blocks the participants were asked to take a break by taking their heads off the headrest. Each stimulus array was displayed on the screen for 5000ms, and the experiment session lasted approximately between 40 and 50 minutes. At the end of the session, participants were thanked and dismissed.

2.2.5. Data Analysis

Both RT and eye movement data were screened before further analysis. In analysing RT data, incorrect manual responses were excluded. It is common practice to exclude RTs < 200 ms because it is assumed that these represent accidental button presses. This time (200ms) is the typical latency for a “reflexive” saccade, that is, for a saccade to occur in response to the onset of a target (Hutton, 2008). Therefore, RTs faster than this can be considered as button presses irrelevant to target detection. In the current data, however, there were no RTs < 200 ms. For the eye movement data analysis, blinks (loss of corneal reflection) and off-screen gazes were automatically excluded from the transferred data by the eye tracker computer. Moreover, the eye gaze fixations occurred before 30ms after the trial onset time were excluded from the analysis.

The main eye movement indices that were analysed to examine the attentional biases effect were:

- First fixation time: the time gaze fixates an interest area for the first time in a trial.
- First fixation duration: the time gaze dwells on an interest area in the first fixation.
- Dwell time: the time gaze dwells on an interest area during a trial.
- Dwell time percentage: the proportion of the dwell time on an interest area relative to the total amount of the dwell time in a trial.
- Fixation count: the number of fixations on an interest area.

Fixation is considered to have occurred when "a set of consecutive gaze coordinates is confined within a diameter of 1 degree visual angle for a minimum of 200ms" (Noton and Stark, 1971, cited in Horley, et al., 2004, p. 46). The interest area is a part of the displayed image that has been designated by the experimenter as the area about which the experimenter intends to collect the eye movement data. In the present experiment the target and filler faces were specified as interest areas.

Two of the eye movement indices, that is, first fixation time and dwell time, can be considered as the main indicators of threat related attentional biases, and have frequently been referred to as the attentional bias indices in threat related attentional bias studies (as reviewed in the previous chapter). The measures indicate how fast attention is oriented toward a stimulus, and how long the stimulus holds attention, and address the debate of the underlying mechanism of threat related attentional biases (i.e., whether attentional bias is due to fast orientation to threat stimuli, or due to the stimuli holding attention). In the present thesis, therefore, these indices were used as the main measures of threat related attentional biases. Another index, first fixation duration, was used as a secondary measure of the biases. This measure indicates the amount of time is spent on a stimulus in the first encounter, and in the case of threat stimuli, it may measure the hypothesized freezing response (e.g., Fox, et al., 2001).

The two other eye movement indices mentioned above, that is, dwell time percentage and fixations count, are expected to be correlated with dwell time, and to provide similar information as this index. Therefore, the two indices were not considered as the main attentional bias indices, and were only used in complementary analyses, for instance, in inferring visual attentional scanpaths patterns from the eye movement indices. For such inferences, taking into account a combination of the indices is necessary. The hyperscanning pattern, for instance, can be inferred when dwell times on two types of interest areas are equal, but the number of fixations on one type of interest area is higher than this number on the other type. As another example of the scanpaths patterns, when the first fixation durations is faster and longer on one type of interest area than on a second type of interest area, but the dwell times are shorter on the first type of interest area than the second type, a hypervigilant-avoidant pattern of attention towards the first type of interest area can be inferred. Inferring visual scanpaths from different eye movement indices is a common approach in analysing the eye movement data in the field of threat related attentional bias studies. For instance, vigilant (e.g., Pflugshaupt et al., 2007) hypervigilant-avoidant (e.g., Pflugshaupt et al.,

2007) and hyperscanning (e.g., Horley et al., 2004) patterns of attention allocation have been inferred from eye movement indices data in the past research.

Using several eye movement indices to test the overt attentional bias effects raises the issue of increasing the possibility of type I error due to conducting numerous statistical analyses on a same data set. To resolve this error inflation issue, also known as the familywise error, the recommended strategy is to correct the tests' α values using methods such as Bonferroni's correction (Field, 2009). However, in eye-tracking studies investigating threat related attentional biases (e.g., Rinck & Becker, 2006; Pflugshaupt et al., 2007; Rinck et al., 2009, Derakshan & Koster, 2010), it is customary not to use a stricter α to control the Type I error rate. For instance, in the recent study by Derakshan and Koster (2010), the data of seven eye movement indices were analysed to examine the pattern of attentional deployment to threatening facial stimuli with no correction applied. The 'family' in the term 'familywise error rate' refers to a set of hypotheses that are co-dependent (such as in pairwise comparisons after an omnibus test) or very similar in content. The reason why eye-tracking studies so often do not correct alpha rates across eye-tracking indices is that each index is perceived to pertain to different mechanisms (for example, dwell time pertains to disengagement whereas first fixation taps orienting responses). As such, different eye-tracking indices are not perceived to pertain to the same family of hypotheses, and therefore, a correction was not applied to the α .

A related issue is using power analysis to make sample size estimations. Power analysis is straightforward enough for the general linear model (e.g., ANOVA, regression). However, for hierarchical multilevel models, the situation is more complex: although specialist software exists to compute power analysis for simple hierarchical models, none exists when models are as complex as those used in this thesis (i.e., multiple predictors were used, complex covariance structures were applied etc.). In addition, because of the presence of cross-level interactions, it is questionable whether power analysis for hierarchical models ever yields useful information (Field, Miles, & Field, 2012).

There is a more general issue around whether correcting for Type I errors and estimating power is useful. Correcting the α and estimating the sample size to achieve a certain degree of power addresses a problem specific to null hypothesis significance testing (NHST). NHST involves reducing an effect that lies on a continuum into a categorical decision (it becomes 'significant' or 'not significant') based on an arbitrary

criterion (.05). There is a growing awareness that this practice is at best unhelpful and at worst damaging (Cohen, 1990, 1994; Meehl, 1978; Ziliak & McCloskey, 20008) and the APA taskforce on statistical inference now recommends reporting and interpreting effect sizes (Wilkinson, 1999).

As such, no correction was made on the α s across different eye-tracking indices in the present thesis and sample size estimates for the current studies were based on the sizes of the samples used in the past research for similar experiments. These decisions were made (1) due to the conventions in the literature; (2) because power analysis could not be done for models as complex as the ones fitted in this thesis; and (3) it was felt unnecessary given the growing awareness of the limitations of NHST.

To analyse the RT and eye movement data in the current study, a mixed model multilevel regression analysis, implemented in R (R Development Core Team, 2010), was employed. This is the method recommended by Field and Wright (2011) for analysing similar experimental data. In the multilevel regression analysis, participants were considered as level one and trials as level two predictors in predicting the outcome variables of RT and the aforementioned eye movement indices. In the analysis, the target emotional expression type (whether the target face in the stimulus array was a happy, angry, or neutral face), target presence, and set size were entered as fixed factors, and participants as a random factor. The analysis followed a hierarchical sequence. It started with the most basic regression model, which included only the intercept, which was random within participants. Next the fixed factors were added to the model, and wherever the fixed factor was a categorical variable (e.g., target presence), a dummy variable was created according to which the baseline category value (e.g., target present trials) was 0 and the other categories' values (e.g., target absent trials) were 1. In the analyses, there was not any fixed factor with more than three levels, therefore, at most two dummy variables were created for any categorical fixed factor. After entering the fixed factors, and their interaction, to the model, the covariance structure of the trial variable was modelled by including a first order autoregressive covariance structure (AR1). As the next step, the trial variable was added to the model along with its interaction with the fixed factors. The trial variable indicates the effect of trial sequence on the outcome variable, and allows both linear and quadratic fits of the trial sequence distribution. Finally, trait anxiety and the interaction of this variable with the fixed factors were added to the model, as the factors mediating the outcome variable.

Based on the principal of parsimony (Crawley, 2007), that we should retain the model that best fits the data with the minimum amount of predictors, an effect is retained only if it significantly improves the model. Thus, the hierarchical structure of this mixed model means that after adding each predictor to the model, the fit of the model was compared to the model before the predictor was factored in to see whether the added predictor improves the fit of the model. If the fit of the model improved significantly, the model including the added predictor was retained, otherwise in the next step the model was built up based on the previous model which made a significant difference in the prediction power of the model.

The original model summaries reported by the R software include the model's degrees of freedom, AIC, BIC, log-likelihood, log-ratio (LR) and p value. However, to keep the results reporting as concise as possible, only log-likelihood, LR, and p values are reported in the studies' results. These are the statistics that were considered to be the most informative statistics regarding the models' improvements. The model column also shows the effect added at each step to the regression model. The results of the final model for each outcome variable are reported in a regression analysis results table. Similar RT and eye movement data treatment processes, and similar data analysis methods have been used in the other experiments of this thesis.

2.3. Results

In all data analyses of this thesis α is set at .05 level as the criterion of significance.

2.3.1. RT data

The participants' RTs were fastest when deciding whether an angry face was present or absent amongst its relevant filler stimuli. The mean RTs to decide about the presence or absence of the targets were as follows: 1694.64 ($SD = 667.96$) for angry faces; 1926.979 ($SD = 698.45$) for happy faces; and 1961.34 ($SD = 726.73$) for neutral faces.

A mixed model multilevel regression analysis (as described above) was administered to compare the RT means. Skewness of RT values was 0.75, and log-transformation improved the values' skewness ($skew = -0.23$); therefore, log-transformed values were used in the regression analysis. Taking the model in turn in this

analysis, the log-likelihood for the baseline model was -5446.65 ; adding the fixed effect of emotion type (emotional expressions of the target faces used in each experiment's set: angry, happy, and neutral) significantly improved the model's fit (log-likelihood = -5179.57 , LR = 534.17 , $p < .0001$) so did adding the fixed effects of target presence (log-likelihood = -3984.86 , LR = 2389.41 , $p < .0001$), set size (log-likelihood = -3241.13 , LR = 1487.47 , $p < .0001$), and the interaction of these three variables (log-likelihood = -3119.27 , LR = 243.72 , $p < .0001$). Modelling the covariance structure of trials also significantly improved the model's fit (log-likelihood = -2863.87 , LR = 510.79 , $p < .0001$), and so did factoring in trial sequence (log-likelihood = -2705.81 , LR = 316.13 , $p < .0001$). Having modelled the covariance structure and trial sequence effects, the interactions of trial sequence and the fixed factors were added to the model as fixed effects. Adding the interaction of trial sequence and emotion type significantly improved the model's fit (log likelihood = -2696.88 , LR = 17.86 , $p < .01$), so did adding the interaction of trial sequence and target presence (log-likelihood = -2671.19 , LR = 51.38 , $p < .0001$), and the interaction of trial sequence and set size (log-likelihood = -2666.07 , LR = 10.23 , $p < .05$). However, neither adding 3- and 4-way interactions of trial sequence with the model's fixed effects (emotion type, target presence, and set size) improved the model's fit (log-likelihood = -2650.94 , LR = 30.26 , $p > .05$), nor factoring in anxiety, and the interaction of anxiety and trial sequence made a significant improvement in the model (log-likelihood = -2664.89 , LR = 2.37 , $p > .05$). Factoring in the interaction of anxiety and emotion type, however, did improve the model's fit significantly (log-likelihood = -2660.49 , LR = 11.18 , $p < .05$). Adding the interaction of anxiety and target presence, and the interaction of anxiety and set size did not improve the model's fit significantly, neither did adding 3- and 4-way interactions of anxiety and the model's fixed effects (log-likelihood = -2653.44 , LR = 14.08 , $p > .05$). The final model which fit the RT data best was a random intercept model with fixed slopes for target presence, emotion type, set size, and the interaction of anxiety and emotion type. In this model covariance structure was explicitly modelled.

Similar sequences as described in the model above have been followed in the multilevel regression models used for analysing the other attentional bias indices data of the current experiment. However, to keep the analyses' report concise, the other sequential models will be presented in tables.

The parameters of the final model are summarised in Table 2.1. In this regression analysis, target present trials, set size 4, and angry facial expression were the baseline categories of the three categorical fixed effects. It is worth mentioning that in the table below (similar to other regression summary tables in this thesis) only the effects that are related to the research's hypotheses, or are theoretically interesting, are reported. For instance, the effect of set size and target presence were significant in all RT analyses, but these effects are not reported in the summary tables (although they were factored into the regression models), as they have been shown repeatedly in the previous studies (e.g., Hadwin et al., 2003), and the current research did not aim to re-examine these effects.

Table 2.1. Summary of the regression model predicting RTs to decide about the presence of the target, with angry emotion expression as the baseline category.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	7.2306	0.1086	13836	66.55	< .0001
Emotion type – Happy face	0.2434	0.0484	13836	5.03	< .0001
Emotion type – Neutral face	0.2062	0.0476	13836	4.33	< .0001
Trial sequence – Linear trend	-5.0358	2.3766	13836	-2.12	< .05
Trial sequence – Quadratic trend	1.8244	2.2560	13836	0.81	<i>ns</i>
Emotion type – Happy face × target presence	-0.0612	0.0206	13836	-2.97	< .01
Emotion type – Neutral face × target presence	-0.0565	0.0207	13836	-2.73	< .01
Emotion type – Happy face × Anxiety scores	-0.0039	0.0013	13836	-2.95	< .01
Emotion type – Neutral face × Anxiety scores	-0.0025	0.0013	13836	-1.91	0.0561

As shown in the table above, the differences between the baseline category (angry emotion expression) and both happy and neutral emotion expressions were significant. This indicates that the RTs to decide whether an angry face is present amongst its relevant filler stimuli was significantly faster than making the decision for happy and neutral faces. Trial sequence also had a significant effect on RTs, suggesting that RTs varied over trials, but the effect was significant only as a linear trend. The interaction of emotion type and target presence was also significant at both emotion type comparison levels, suggesting that the significant differences between the RTs of the angry emotion condition, and the RTs of the happy and neutral emotion conditions varied for target present and target absent trials. Finally and most importantly, there was a significant interaction between anxiety scores and the difference between the RTs of angry and

happy emotion conditions. This interaction suggests that anxious individuals made significantly faster decisions in the angry compared to the happy emotion condition. There was a similar effect of anxiety on the difference between the RTs of the angry and neutral emotion conditions, however this difference was marginally significant.

To examine whether the difference between RTs is specific to the comparisons of angry with happy, and angry with neutral faces, or it is an effect that is also found when comparing neutral and happy faces, another regression analysis was conducted. In this analysis, neutral emotion expression was the baseline category, and the RTs of this emotion expression were compared with the RTs of other two emotion expressions. Because the regression analysis is quite similar to the analysis in which angry face condition was used as the baseline category, the process of building the regression model is not reported here, and only the relevant findings of the final model are presented in Table 2.2.

Table 2.2. The parameters of the regression model predicting the RTs to decide about the presence of the target, with neutral emotion expression as the baseline category.

	<i>b</i>	<i>SE b</i>	<i>Df</i>	<i>t</i>	<i>p</i>
Emotion type – Happy face	0.0372	0.0456	13836	0.82	<i>ns</i>
Emotion type – Happy face \times target presence	-0.0047	0.0205	13836	-0.23	<i>ns</i>
Emotion type – Happy face \times Anxiety scores	-0.0014	0.0012	13836	-1.14	<i>ns</i>

The findings indicate that the baseline category and happy emotion expression were not significantly different, which suggests that RTs when deciding whether a neutral face is present or absent amongst its relevant fillers were not significantly different from RTs when deciding about the presence or absence of a happy face amongst its relevant fillers. The interactions of emotion type and both target presence and anxiety were also non-significant.

When analysing the differences between the RTs of the angry emotion condition, and the neutral and happy conditions (in the first regression analysis), it was found that emotion type significantly interacted with target presence. To follow up the interaction effect, separate regression analyses were carried out on target present and target absent trials. Similar to the results reported for the all trials condition, in the target present condition, the participants' RTs were fastest when detecting an angry face amongst its relevant filler stimuli. In these trials, the mean target detection RTs in the angry emotion

condition was 1422.07 ($SD = 579.03$); in the happy emotion condition was 1696.41 ($SD = 615.40$); and in the neutral emotion condition was 1729.91 ($SD = 647.68$). Skewness of the RT values was 1.10, and log-transformation notably improved the values' skewness (skew = 0.02); therefore, log-transformed values were used in the regression. Table 2.3 shows the sequential models fitted to the data.

The final model was a random intercept model with fixed slopes for target presence, emotion type, and set size, in which covariance structure was explicitly modelled. The relevant parameters of this model are presented in Table 2.4.

Table 2.3. Summary of the model selection process for the RTs to detect the target faces.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	-2390.16		
Emotion Type (FE)	-2128.17	523.99	< .0001
Set size (FE)	-1952.54	351.25	< .0001
Emotion type \times Set size (FE)	-1943.73	17.62	< .01
Covariance structure (Trial)	-1859.85	167.76	< .0001
Trial (FE)	-1714.82	290.07	< .0001
Trial \times Emotion type,	-1707.71	14.22	< .01
Trial \times Set size	-1702.49	10.43	< .05
Trial \times Emotion type \times Set size	-1699.21	6.57	<i>ns</i>
Anxiety	-1701.62	1.73	<i>ns</i>
Anxiety \times Trial	-1701.37	0.51	<i>ns</i>
Anxiety \times Emotion type	-1697.72	7.29	<i>ns</i>
Anxiety \times Set size	-1697.27	0.91	<i>ns</i>
Anxiety \times Emotion type \times Set size	-1694.33	5.88	<i>ns</i>

Table 2.4. Summary of the regression model predicting RTs to detect the target face, with angry emotion expression as the baseline category.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	7.1550	0.0225	6774	318.22	< .0001
Emotion type – Happy face	0.1049	0.0167	6774	6.30	< .0001
Emotion type – Neutral face	0.1190	0.0168	6774	7.07	< .0001
Trial sequence – Linear trend	-6.5852	0.8640	6774	-7.62	< .0001
Trial sequence – Quadratic trend	0.6670	0.7935	6774	0.84	<i>ns</i>

The differences between the baseline category and the happy and neutral emotion conditions were significant, indicating that RTs to detect angry faces amongst their relevant filler stimuli was significantly faster than RTs to detect happy and neutral faces amongst their filler stimuli.

Another regression analysis was conducted to examine whether there was also a significant difference between the detection time of happy and neutral faces. In this analysis the neutral emotion condition was the baseline category. The relevant findings are presented in Table 2.5.

Table 2.5. The parameter of the regression model predicting RTs to detect the target face, with neutral emotion expression as the baseline category.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>T</i>	<i>p</i>
Emotion type – Happy face	-0.0141	0.0164	6774	-0.85	<i>ns</i>

The difference between the baseline and the happy emotion conditions was not significant, which suggests that RTs to detect happy faces amongst their filler stimuli was not significantly different from RTs to detect neutral faces amongst their filler stimuli. In other words, the fast detection time was specific to angry face detection.

Similar to target present trials, in target absent trials, the participants' RTs were fastest in the angry emotion condition. In these trials, the mean RTs to specify that there is no target face amongst the filler stimuli in the angry emotion condition was 1966.16 ($SD = 639.55$); in the happy emotion condition was 2148.672 ($SD = 701.88$); and in the neutral emotion condition was 2181.26 ($SD = 729.58$). The skewness of the RT values was 0.56, but log transformation did not improve the skewness notably ($skew = -0.45$), therefore the original RTs were used in the regression analysis. Table 2.6 shows the sequential models fitted to the data. The final model was a random intercept model with fixed slopes for emotion type, set size, anxiety, and the interaction of anxiety and set size. In this model covariance structure of trials was explicitly modelled. The relevant parameters of this regression model are presented in Table 2.7.

The differences between the baseline category and the happy and neutral emotion conditions were significant. This indicates that the RTs to specify the absence of an angry face amongst its relevant fillers were significantly faster than the RTs to specify the absence of happy and neutral faces amongst their relevant filler stimuli. Moreover, the only effect of anxiety on RTs was its marginally significant interaction with happy

emotion condition. This suggests that the faster RTs when specifying the absence of an angry face in its stimulus array relative to a happy face in its stimulus array was even faster in anxious individuals as compared to the non-anxious ones. This effect was only marginally significant, and such an interaction was not significant for the comparison of the RTs of the angry and neutral emotion conditions.

Table 2.6. Summary of the model selection process for the RTs in target absent trials

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	-55801.51		
Emotion Type (FE)	-55719.96	163.10	< .0001
Set size (FE)	-55000.49	1438.95	< .0001
Emotion type \times Set size (FE)	-54993.27	14.44	< .01
Covariance structure (Trial)	-54855.67	275.20	< .0001
Trial (FE)	-54807.88	95.59	< .0001
Trial \times Emotion type,	-54801.85	12.06	< .05
Trial \times Set size	-54792.23	19.23	< .001
Trial \times Emotion type \times Set size	-54785.89	12.69	<i>ns</i>
Anxiety	-54790.43	3.61	.0574
Anxiety \times Trial	-54789.76	1.34	<i>ns</i>
Anxiety \times Emotion type	-54787.67	4.17	<i>ns</i>
Anxiety \times Set size	-54783.13	9.09	< .05
Anxiety \times Emotion type \times Set size	-54781.39	3.48	<i>ns</i>

Table 2.7. Summary of the regression model predicting RTs in target absent trials, with angry emotion expression as the baseline category.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	1859.79	230.60	6984	8.06	< .0001
Emotion type – Happy face	301.66	122.79	6984	2.46	< .05
Emotion type – Neutral face	323.10	119.88	6984	2.70	< .01
Trial sequence – Linear trend	-4289.40	4361.58	6984	-0.98	<i>ns</i>
Trial sequence – Quadratic trend	130.37	4114.86	6984	0.03	<i>ns</i>
Anxiety	-4.49	6.58	6984	-0.68	<i>ns</i>
Emotion type – Happy face \times Anxiety	-6.27	3.48	6984	-1.82	0.069
Emotion type – Neutral face \times Anxiety	-5.68	3.37	6984	-1.69	<i>ns</i>

Regardless of the effect of anxiety on RTs, it was found that participants realise the absence of angry faces significantly faster than neutral and happy faces in their stimulus arrays. To examine whether this difference can also be found between happy and neutral emotion expressions, another regression analysis was conducted. In this analysis, the neutral emotion expression was the baseline category, and the parameters of the final model are presented in Table 2.8.

Table 2.8. The parameters of the regression model predicting RTs in target absent trials, with neutral emotion expression as the baseline category.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Emotion type – Happy face	-21.44	115.06	6984	-0.19	<i>ns</i>
Emotion type – Happy face × Anxiety	-0.588	3.22	6984	-0.18	<i>ns</i>

There was not any significant difference between the participants' RTs when responding to the absence of a happy face relative to a neutral face amongst their relevant filler stimuli. Therefore, the faster RT effect was specific to angry facial expressions.

2.3.1.1. Summary of the RT results

RTs to detect angry facial expression, and to decide whether the facial expression is present or absent amongst its relevant filler stimuli, were significantly faster than the RTs to happy and neutral facial expressions. These RT effects were specific to angry faces, and the differences between happy and neutral facial expressions were not significant. Trait anxiety significantly interacted with the RTs in the all trials condition (in which both target present and target absent trials were included) for the difference between angry and happy face's categories. Therefore, high trait anxious children were significantly faster to decide whether an angry face is present amongst its fillers than to decide whether a happy face is present amongst its fillers. The effect of trait anxiety in the difference between angry and neutral faces was only marginally significant.

2.3.2. Eye movement data

Angry face targets have been compared against the two other facial targets in terms of five eye movement indices to examine whether the attentional bias effect found in the RT data can also be displayed in the participants' visual scanpaths. The eye movement

indices include the first fixation time, first fixation duration, fixation count, dwell time, and dwell time percentage.

2.3.2.1. First fixation time on the target

Participants fixated most quickly on angry target faces. The mean of the first fixation times on angry faces was 675.44 ($SD = 440.36$) on happy faces was 909.90 ($SD = 573.96$) and on neutral faces was 854.90 ($SD = 566.11$). Skewness of the first fixation time values was 1.67, and log-transformation notably improved the values' skewness (skew = -0.02), therefore, the log-transformed values were used in the regression analysis. Table 2.9 shows the sequential models fitted to the data. The final model was a random intercept model with fixed slopes for emotion type, set size, anxiety, and the interaction of emotion type and set size. In this model trial sequence effect, but not the covariance structure of the trials, was modelled. The parameters of this regression model are presented in Table 2.10.

Table 2.9. Summary of the model selection process for the time of the first fixations on targets.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	-6933.05		
Emotion Type (FE)	-6807.27	251.56	< .0001
Set size (FE)	-6503.56	607.41	< .0001
Emotion type \times Set size (FE)	-6492.72	21.68	< .001
Covariance structure (Trial)	-6492.03	1.37	<i>ns</i>
Trial (FE)	-6459.88	65.68	< .0001
Trial \times Emotion type,	-6452.92	13.92	< .01
Trial \times Set size	-6451.90	2.03	<i>ns</i>
Trial \times Emotion type \times Set size	-6446.76	10.29	<i>ns</i>
Anxiety	-6450.77	4.30	< .05
Anxiety \times Trial	-6448.81	3.92	<i>ns</i>
Anxiety \times Emotion type	-6446.92	3.78	<i>ns</i>
Anxiety \times Set size	-6446.26	1.31	<i>ns</i>
Anxiety \times Emotion type \times Set size	-6444.82	2.89	<i>ns</i>

Table 2.10. Summary of the regression model predicting the time of the first fixation on targets, with angry emotion expression as the baseline category.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	6.3961	0.0976	7287	65.53	< .0001
Emotion type – Happy face	0.1555	0.0292	7287	5.33	< .0001
Emotion type – Neutral face	0.0912	0.0292	7287	3.12	< .01
Trial sequence – Linear trend	-2.9652	1.2267	7287	-2.42	< .05
Trial sequence – Quadratic trend	-0.5804	1.1298	7287	-0.51	<i>ns</i>
Anxiety	-0.0057	0.0027	7287	-2.11	< .05

The differences between the baseline category and both happy and neutral emotion expressions were significant. This suggests that angry target faces were fixated significantly faster than the other two target faces. Moreover, anxiety had a significant effect in reducing the first fixation times on all targets (in other words, anxious participants had faster fixation times on all targets in general), however, as seen in the sequential model's table, the interaction effect of anxiety and emotion type did not improve the model, therefore, was not modelled in the analysis. This suggests that anxiety did not interact with the response to any facial emotion conditions, and anxious participants did not fixate on angry faces as compared to the other target faces any faster than the non-anxious ones.

Regardless of the effect of anxiety, the participants fixated faster on angry target faces relative to the other two facial expression targets. To examine whether there is a significant difference between the first fixation times on happy and neutral faces another regression analysis was conducted. In this analysis neutral emotion expression was the baseline category. The findings are presented in Table 2.11.

Table 2.11. The parameters of the regression model predicting the time of the first on targets, with neutral emotion expression as the baseline category.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Emotion type – Happy face	0.0643	0.0289	7287	2.22	< .05

The difference between the time of the first fixation on the neutral and happy emotion conditions was also significant, and the first fixation time effect was not specific to angry facial expression.

2.3.2.2. Duration of the first fixation on the target

The first fixations on angry target faces lasted longer than on the other two target faces. The mean of the first fixation durations on angry faces was 397.29 ($SD = 472.73$), on happy faces was 381.12 ($SD = 434.65$), and on neutral faces was 350.52 ($SD = 377.83$). Skewness of the first fixation duration values was 4.18, and log-transformation improved the values' skewness (skew = 0.81); therefore, the log-transformed values were used in the analysis. Table 2.12 shows the sequential models fitted to the data.

Table 2.12. Summary of the model selection process for the duration of the first fixations on targets.

Model	Log-Likelihood	LR	<i>p</i>
Baseline	-7685.21		
Emotion Type (FE)	-7678.46	13.51	< .01
Set size (FE)	-7671.54	13.83	< .01
Emotion type \times Set size (FE)	-7670.32	2.44	<i>ns</i>
Covariance structure (Trial)	-7670.69	1.70	<i>ns</i>
Trial (FE)	-7657.96	27.17	< .0001
Trial \times Emotion type,	-7655.46	4.99	<i>ns</i>
Trial \times Set size	-7653.97	2.98	<i>ns</i>
Trial \times Emotion type \times Set size	-7650.96	6.01	<i>ns</i>
Anxiety	-7657.60	0.71	<i>ns</i>
Anxiety \times Trial	-7657.12	0.95	<i>ns</i>
Anxiety \times Emotion type	-7656.75	0.74	<i>ns</i>
Anxiety \times Set size	-7656.50	0.50	<i>ns</i>
Anxiety \times Emotion type \times Set size	-7655.36	2.28	<i>ns</i>

Table 2.13. Summary of the regression model predicting the durations of the first fixation on targets, with angry emotion expression as the baseline category.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	5.6015	0.0322	7298	173.85	< .0001
Emotion type – Happy face	-0.0089	0.0198	7298	-0.45	<i>ns</i>
Emotion type – Neutral face	-0.0445	0.0200	7298	-2.23	< .05
Trial sequence – Linear trend	3.6317	0.7009	7298	5.18	< .0001
Trial sequence – Quadratic trend	-0.3231	0.6844	7298	-0.47	<i>ns</i>

The final model was a random intercept model with fixed slopes for emotion type, and set size, in which the trial sequence effect, but not the covariance structure of trials, was modelled. The parameters of this regression model are presented in Table 2.13.

The results indicate that the first fixation durations on angry faces lasted significantly longer than the first fixation durations on neutral faces, but the first fixation durations on angry and happy target faces were not significantly different. Moreover, as mentioned above, the effect of anxiety was not factored in the analysis, suggesting that anxiety did not have a significant effect on the first fixation durations.

To examine whether first fixation durations on happy and neutral target faces were also significantly different, another regression analysis was conducted. In this analysis, the neutral emotion condition was the baseline category. The findings of the analysis are presented in Table 2.14.

Table 2.14. The parameters of the regression model predicting the durations of the first fixation on targets, with neutral emotion expression as the baseline category.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Emotion type – Happy face	0.0356	0.0194	7298	1.83	0.0666

The difference between the first fixation durations on neutral and happy target faces was marginally significant. Therefore, there was a trend that the gaze durations also lasted longer on happy faces than the neutral faces during the first fixations on the faces.

2.3.2.3. Number of fixations on the target

Fixation counts were higher on angry faces than happy and neutral faces. The mean of the fixation counts on angry faces was 3.53 ($SD = 1.86$), on happy faces was 3.37 ($SD = 1.71$), and on neutral faces was 3.43 ($SD = 1.67$). Skewness of the fixation count values was 0.703, and log-transformation improved the values' skewness (skew = -0.48), therefore, the log-transformed values were used in the regression analysis. Table 2.15 shows the sequential models fitted to the data.

The final model was a random intercept model with fixed slopes for emotion type, set size, and three-way interaction of anxiety, emotion type and set size. In this model covariance structure of trials was explicitly modelled. The parameters of this regression model are presented in Table 2.16.

Table 2.15. Summary of the model selection process for the number of fixations on targets.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	−3527.36		
Emotion Type (FE)	−3524.20	6.31	< .05
Set size (FE)	−3486.61	75.18	< .0001
Emotion type × Set size (FE)	−3482.57	8.08	<i>ns</i>
Covariance structure (Trial)	− 3464.13	44.97	< .0001
Trial (FE)	−3453.52	21.21	< .0001
Trial × Emotion type,	−3446.72	13.60	< .01
Trial× Set size	−3443.24	6.97	<i>ns</i>
Trial × Emotion type × Set size	−3441.18	4.11	<i>ns</i>
Anxiety	−3446.27	0.91	<i>ns</i>
Anxiety × Trial	−3445.57	1.39	<i>ns</i>
Anxiety × Emotion type	−3443.56	4.02	<i>ns</i>
Anxiety × Set size	−3440.58	5.96	.0508
Anxiety × Emotion type × Set size	−3436.41	8.33	<i>ns</i>

Table 2.16. Summary of the regression model predicting the number of fixations on targets, with angry emotion expression as the baseline category.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	1.7523	0.1324	7363	13.23	< .0001
Emotion type – Happy face	-0.1736	0.0736	7363	-2.36	< .05
Emotion type – Neutral face	-0.0948	0.0721	7363	-1.31	<i>ns</i>
Trial sequence – Linear trend	-3.1775	2.6783	7363	-1.19	<i>ns</i>
Trial sequence – Quadratic trend	-4.6550	2.5747	7363	-1.81	<i>ns</i>

The findings indicate that angry faces were fixated significantly more frequently than happy faces, but the number of fixations was not significantly different on angry and neutral faces. It is also worth mentioning that although the interaction of anxiety and set size made a marginally significant improvement in the model, the interaction was not significant as the predictor of fixation counts in the final model.

Another regression analysis was conducted to examine whether the difference between the number of fixations on happy and neutral faces was significant. In this analysis the neutral emotion expression was the baseline category. The findings of this analysis are presented in Table 2.17.

Table 2.17. The parameters of the regression model predicting the number of fixations on targets, with neutral emotion expression as the baseline category.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Emotion type – Happy face	-0.0788	0.0688	7363	-1.15	<i>ns</i>

As shown in the table above, the difference between the number of fixations on happy and neutral faces was not significant, therefore, the fixation count effect was specific to the difference between angry and happy facial expressions.

2.3.2.4. Dwell times on the target

Angry target faces were dwelt for longer times than happy and neutral target faces. The mean of the dwell times on angry faces was 1521.20 ($SD = 877.08$), on happy faces was 1452.76 ($SD = 827.51$), and on neutral faces was 1466.97 ($SD = 846.61$). Skewness of the dwell time values was 0.55, however, the log transformation did not improve the values' skewness ($skew = -0.73$), therefore, the original dwell time values were used in the regression analysis. Table 2.18 shows the sequential models fitted to the data. The final model was a random intercept model with fixed slopes for emotion type and set size, in which covariance structure of trials was explicitly modelled. The parameters of this regression model are presented in Table 2.19.

Table 2.18. Summary of the model selection process for dwell times on targets.

Model	<i>Log-Likelihood</i>	<i>LR</i>	<i>p</i>
Baseline	-60020.55		
Emotion Type (FE)	-60014.77	11.55	< .05
Set size (FE)	-59947.67	134.22	< .0001
Emotion type \times Set size (FE)	-59944.73	5.87	<i>ns</i>
Covariance structure (Trial)	-59889.02	117.30	< .0001
Trial (FE)	-59808.83	160.38	< .0001
Trial \times Emotion type,	-59804.85	7.96	<i>ns</i>
Trial \times Set size	-59803.60	2.51	<i>ns</i>
Trial \times Emotion type \times Set size	-59799.18	8.82	<i>ns</i>
Anxiety	-59808.36	0.93	<i>ns</i>
Anxiety \times Trial	-59807.68	1.36	<i>ns</i>
Anxiety \times Emotion type	-59806.79	1.79	<i>ns</i>
Anxiety \times Set size	-59804.92	3.73	<i>ns</i>
Anxiety \times Emotion type \times Set size	-59801.69	6.47	<i>ns</i>

Table 2.19. Summary of the regression model predicting dwell times on targets, with angry emotion expression as the baseline category.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	1622.06	52.46	7377	30.91	< .0001
Emotion type – Happy face	-39.72	23.17	7377	-1.71	.0865
Emotion type – Neutral face	9.19	23.34	7377	0.39	<i>ns</i>
Trial sequence – Linear trend	9558	823.02	7377	11.61	< .0001
Trial sequence – Quadratic trend	-4267.83	804.43	7377	-5.31	< .0001

The dwell times on angry, happy, and neutral target faces were not significantly different. It should be noted that the *p* value of the comparison between angry and happy target faces (i.e., 0.0865) was considered as non-significant in this analysis, and has been reported for the reader's information. Therefore, no follow-up analysis was conducted to compare the happy and neutral emotion conditions in terms of the dwell time on the target index.

2.3.2.5. The percentage of dwell time on the target

Angry target faces had the highest dwell time percentages. The mean of the percentage of dwell time on angry faces was 0.4424 (*SD* = 0.2321), on happy faces was 0.4230 (*SD* = 0.2189), and on neutral faces was 0.4235 (*SD* = 0.2234). Skewness of the dwell time percentage values was 0.29, however, log transformation did not improve the values' skewness (skew = -0.86), therefore, the original values were used in the regression analysis. Table 2.20 shows the sequential models fitted to the data.

The final model was a random intercept model with fixed slopes for emotion type and set size, in which covariance structure of trials was explicitly modelled. The parameters of this regression model are presented in Table 2.21.

The differences between the dwell time percentages on angry, happy and neutral target faces were not significant. The *p* value of the comparison between angry and happy target faces in the table (i.e., 0.081) was considered as non-significant, and has been reported for the reader's information. Therefore, no follow-up analysis was conducted to compare the percentage of dwell times on the happy and neutral target faces.

Table 2.20. Summary of the model selection process for the percentages of dwell time on the target faces.

Model	<i>Log-Likelihood</i>	<i>LR</i>	<i>p</i>
Baseline	1202.28		
Emotion Type (FE)	1209.67	14.78	< .001
Set size (FE)	1287.13	154.91	< .0001
Emotion type × Set size (FE)	1290.47	6.68	<i>ns</i>
Covariance structure (Trial)	1342.96	111.67	< .0001
Trial (FE)	1433.35	180.77	< .0001
Trial × Emotion type,	1437.11	7.52	<i>ns</i>
Trial× Set size	1438.58	2.94	<i>ns</i>
Trial × Emotion type × Set size	1443.51	9.85	<i>ns</i>
Anxiety	1434.02	1.34	<i>ns</i>
Anxiety × Trial	1434.81	1.58	<i>ns</i>
Anxiety × Emotion type	1435.29	0.97	<i>ns</i>
Anxiety × Set size	1437.29	3.98	<i>ns</i>
Anxiety × Emotion type × Set size	1441.05	7.52	<i>ns</i>

Table 2.21. Summary of the regression model predicting the percentages of the dwell times on targets, with angry emotion expression as the baseline category.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	0.4716	0.0129	7377	36.54	< .0001
Emotion type – Happy face	-0.0109	0.0062	7377	-1.75	.0810
Emotion type – Neutral face	-0.0006	0.0062	7377	-0.11	<i>ns</i>
Trial sequence – Linear trend	2.7495	0.2209	7377	12.44	< .0001
Trial sequence – Quadratic trend	-1.1765	0.2160	7377	-5.45	< .0001

2.3.2.6. Summary of the eye movement data

The first fixation times were faster on angry faces than happy and neutral faces. Happy faces were also fixated faster than neutral faces. The durations of the first fixations were longer on angry faces than neutral faces, but not longer than happy faces. The durations of the first fixations were also marginally significantly longer on happy faces than neutral faces. Angry faces were fixated more frequently than happy faces, but the number of fixations was not higher on angry faces than the neutral faces. The difference between the number of fixations on happy and neutral faces was also non-significant. Moreover, no significant difference was found between the facial expressions in terms of the total fixation durations and the percentage of the fixation

durations. Finally, trait anxiety did not interact significantly with any of the eye movement responses.

2.4. Discussions

All the RT results indicated attentional bias towards angry faces. The participants' decisions about the presence or absence of the angry facial expressions in the stimulus arrays were significantly faster than their decisions for the happy and neutral expressions. This effect is similar to what Hadwin et al. (2003) found in the original study. In the current study, however, the interaction of RT and target presence was significant, which is inconsistent with Hadwin et al.'s findings. Nevertheless, the follow-up analyses showed that the RT effect was significant in both target present and target absent trials. In other words, participants both detected, and responded to the absence of, angry faces in the stimulus arrays significantly faster than the other two facial expressions. The significance of the interaction of target presence and RTs might be because of the unequal levels of the difference between the means of the target absent and target present trials. The higher significance level in the target present condition, as compared to the target absent condition, implies that the difference between the RT means in the target present trials was more pronounced than this difference in the target absent trials. This might have led to the interaction of RT and target presence being significant, but it would not affect the conclusion that all RT results indicate an attentional bias towards angry faces. Moreover, similar to the findings of the original study, this effect was specific to the angry facial expression, and the effect was not found for the difference between happy and neutral faces. Based on these findings, the first hypothesis can be confirmed.

The findings are consistent with several studies that, in general, have found attentional biases towards threat stimuli, indexed by manual RTs, and using various attentional bias paradigms including the Stroop (e.g., Becker, Rinck, Margraf, & Roth, 2001), visual cueing (e.g., Fox, Russo, et al., 2000), and dot probe tasks (e.g., Bradley, et al., 2000). More specifically the findings are consistent with the studies that have displayed attentional bias towards angry facial stimuli using the visual search task in adults (e.g., Fox, Lester, et al., 2000; Hansen & Hansen, 1988; Öhman, Lundqvist, et al., 2001; Tipples, et al., 2002) and children (e.g., Waters & Lipp, 2008; LoBue, 2009). The findings, however, are inconsistent with the visual search studies that have used

facial stimuli and have not found the angry face attentional bias effect (e.g., Calvo, et al., 2008; Byrne & Eysenck, 1995; Juth, et al., 2005, Experiments 1, 2, & 3). As discussed before, such inconsistencies are not uncommon in the attentional bias studies that have used facial emotional expressions as stimuli. There should be some other yet unknown factors that interact with the attentional bias effects. These factors need to be identified to explain inconsistencies and answer the questions such as why some studies have found attentional prioritisation for happy but not angry faces (e.g., Byrne & Eysenck, 1995), some to angry but not happy (e.g., Waters & Lipp, 2008), and some to both types of facial stimuli as compared to other facial expressions (Hunt, et al., 2007).

Moreover, as Hadwin et al. have discussed in the original study, it is possible that the attentional bias effect found is merely due to the distinctions between the facial stimuli features, and not because of the emotion expressed by the stimuli. Derakhshan and Koster (2010) argued that finding an interaction between anxiety and attentional bias effect, so that anxious individuals show significantly higher attentional bias towards the threatening faces, would rule out the possibility that the attentional prioritisation is merely due to the stimuli features distinctions. In their study, based on the eye movement data, anxious individuals did not display attentional bias to angry faces more so than the non-anxious ones. Therefore, the researchers attributed the angry face prioritisation in the eye movement data to the differences between the facial stimuli features. This, however, is not the only interpretation of such a pattern of results. Others (e.g., Rohner, 2002) have considered such a pattern as a general attentional bias, that is, an attentional prioritisation of angry faces in both anxious and non-anxious people. This interpretation is theoretically sound, as the bias to angry faces has been hypothesised to originate from the human's evolutionary past, and therefore, to exist in all human beings. Nonetheless, the distinctions between the features of angry and other facial emotional stimuli can also be the source of the attentional prioritisation. Therefore, a conclusion in favour of the existence of a threat related attentional bias towards angry faces can be made with more confidence if it is shown that anxious individuals display a higher attentional prioritisation than the non-anxious ones.

This is in line with the second hypothesis of this study. Based on this hypothesis, it was predicted that anxious individuals detect, and respond to the absence of angry faces comparing with happy and neutral faces significantly faster than non-anxious participants. The interaction of trait anxiety scores and RTs were examined to test this hypothesis, and showed that the effect of anxiety on the attentional biases was not

robust. Anxiety had a significant effect only in one of the RT analyses. In the all trials condition (i.e., including both target present and target absent trials), anxious participants' RTs were significantly faster when deciding about the presence or absence of an angry target face, relative to when deciding about the presence or absence of a happy target face, in their stimulus arrays.

This significant effect was not found in the original study, and it might have resulted from the use of a larger sample size, which has probably increased the statistical power in the current study. This argument seems more reasonable by considering the fact that this significant effect was found only in the all trials condition, which included twice as many trials as each one of the target present and target absent conditions. Such an effect of anxiety on RTs was not significant in target present trials, and was only marginally significant in the target absent condition. By including both conditions, statistical power of the test has probably increased, and resulted in the significant effect.

There are some similarities between the pattern of the interaction of anxiety and responding to emotional stimuli in target present and target absent trials in the current study and in Hadwin et al.'s original study. In both studies, anxious and non-anxious children's RTs were not different when detecting the angry facial targets relative to the other emotional targets (in target present trials), but anxious participants responded to the absence of angry target faces in their stimulus arrays, faster than the absence of the happy target faces in their stimulus arrays. The difference between the two studies, however, was that the effect in the original study was significant, and in the replication was marginally significant. Moreover, in the original study, the anxiety effect was significant for both comparisons in the target absent condition (the comparison of angry and happy, and the comparison of angry and neutral faces), whereas in the current study, the effect was specific to the comparison of angry and happy emotion expressions. Based on the findings, the second hypothesis can also be partly supported, and although in sum the support is not robust, it can be concluded with confidence that anxious children responded to angry facial expressions differently relative to the other facial expressions. Thus, the faster RTs to the angry facial stimuli might not be merely due to the distinctions between the features of angry and other facial stimuli, it rather might be due to the emotion expressed by the stimuli. Overall, the support for the first hypothesis seems more robust and consistent with the original study's findings than the support for the second hypothesis.

Similar to the RT data, three eye movement indices showed attentional bias effect towards angry faces. The first fixation time on angry faces was faster than on both happy and neutral facial expressions. Unlike the RT results, however, the first fixation time effect was not specific to angry faces, and the difference between happy and neutral faces was also found to be significant. The durations of the first fixation on angry faces were also longer than the durations on neutral faces, but the difference between happy and angry faces was not significant. The durations were also marginally significantly longer on happy faces than on neutral faces. This can indicate the attentional capture in the first fixation by emotional faces, and is consistent with the studies that have found attentional bias toward emotional faces in general (e.g., Hunt, et al., 2007). The higher gaze fixation continued on angry faces, but not on happy faces: the number of fixations on angry faces was significantly higher than the fixations on happy faces. The number of fixations on angry and neutral faces, however, was not significantly different. Similarly, the difference between the number of fixations on happy and neutral faces was not significant. Finally, the differences of the dwell times and dwell time percentages across different target faces were not significant (although patterns of mean differences similar to the fixation count index was found for the two dwell time indices). The last three indices results are inconsistent with the findings of Derakhshan and Koster (2010) which showed that emotional facial stimuli (angry and happy faces) were fixated more frequently, and for longer times, than neutral faces before making a manual response. This inconsistency might be due to the differences between the design and stimuli of the two tasks.

With regard to attention deployment patterns, in addition to the signs of vigilance for threat, there seems to be signs of hyperscanning on angry faces as compared to happy faces. As discussed above, while the difference between the dwell times on angry and happy faces was not significant, number of fixations on angry faces was significantly higher than the fixation counts on happy faces. This effect might indicate a pattern of hyperscanning the angry faces. Based on the findings, the third hypothesis is partly supported. In sum, it can be concluded that similar effect as the RT effect was found for the first fixation times, and a first attentional capture effect was found for the emotional targets which continued only for angry faces in the remainder of the stimuli display times.

None of the eye movement effects interacted significantly with anxiety scores. As discussed above, this might indicate that the visual attentional prioritisation found in

favour of angry target faces relative to the other two emotion expressions merely reflect the faces' features distinctions. In contrast, such a lack of anxiety mediation has also been interpreted as an angry face attentional prioritisation in the general population regardless of the anxiety levels.

As mentioned before, a number of participants did not complete the visual search task and asked to stop the task. This might have been because of the length of the task, which might have been tiresome for the participating children. Although the original study conducted by Hadwin et al. used a sample with a similar age range as the present experiment, in their experiment the participants' eye movements were not recorded. The added time needed for recording eye movements might have made the experiment too long for some participants. However, because the experimental conditions were counterbalanced, the tiredness would affect all conditions equally, and would not affect the results of any one of the conditions systematically. Moreover, the effect of trial sequence was factored into all of the multilevel models fitted to RT and eye movement data. Factoring in this variable into these models has estimated the effect of tiredness and controlled for it when estimating parameters for other predictors in the models.

The main aim of this study was to set a comparison basis by examining the RT and eye movement response patterns in children when they display attentional bias towards angry faces. The attentional bias towards these stimuli were considered as a typical pre-established threat related attentional bias, and the RT and eye movement patterns found in the current study were used in the next chapters as a comparison basis against which the induced threat related attentional biases were compared. To sum up the results regarding the patterns, it seems that manual RTs manifested best the anxiety related attentional biases. The time of the first fixation on targets followed the manual RTs more closely than the other eye movement indices, and the attentional bias effect was reflected in the other indices in a rather more complicated way than the time of the first fixation on targets. What is specific about manual RTs as an index of threat related attentional bias is its interaction with trait anxiety which was not found for the eye movement indices. This may be due to the different cognitive processes that are involved in the indices: manual RTs are decision times, and are involved in recognition, whereas eye movements are more reflexive and involuntary responses. Therefore, it might be the case that anxiety interacts more effectively with the responses that are involved in higher cognitive processes.

Chapter 3: Acquiring Fear of, and Attentional Bias towards, Novel Stimuli

3.1. Introduction

Rachman (1977) proposed that fear of stimuli and situations can be learned by receiving threat information, and both retrospective and prospective research has supported this proposal. For instance, in a study by Ollendick and King (1991b), 39% of the participants, who were children sampled from the general population, attributed their fears to the information fear pathway. The prospective research by Field and his colleagues (for a review, see Field & Purkis, *in press*) has also shown that fear of novel stimuli, that is, unfamiliar animals, can be induced by giving threat information. Employing this methodology, it has been found that receiving threat information leads to significant increases in all three fear response systems proposed by Lang (e.g., Lang, Levin, Miller, & Kozak, 1983b); that is, increases in children's fear beliefs (e.g., Field & Lawson, 2003), behavioural avoidance (e.g., Field & Lawson, 2003; Field & Storksen-Coulson, 2007), and heart rates (e.g., Field & Schorah, 2007), which may measure cognitive, behavioural and physiological fear responses, respectively.

Two studies by Field (2006a, 2006c) also showed that children acquired attentional bias towards the pictures of animals about which they received threat information. In these studies, the dot probe paradigm was used, in which the prime pictures were pairs of novel animal images, about which the children had listened to threat, positive or no information. The prime pictures were presented for 500ms and were immediately replaced by the probe stimuli. The participants were instructed to press either the A key on a computer keyboard if the probe was “..” or the L key if the probe was “:” and their RTs to detecting the probes were recorded. The results of both studies showed that children's RTs were significantly faster to the probes which appeared in the vicinity of the threat information than the probes which replaced the positive information animal.

To our knowledge, these are the only published studies that have used a prospective paradigm to induce attentional bias towards novel stimuli. Nonetheless, the dot probe task, which was employed in this study to measure the participants'

attentional biases, has some limitations. This task relies on a specific time in the time course of visual attention (i.e., the prime stimuli display time) to gauge the attentional bias effect. In other words, the manual response in this task indicates the stimulus to which attention has been allocated at the end of the prime display time, but it cannot say where the attention has been allocated before this time. Such a snapshot picture of attention (as described by Bradley, Mogg, & Millar, 2000) is not a sound reflection of the whole course of attention. Due to this limitation, the paradigm's strength in revealing the underlying mechanisms and visual attentional patterns related to threat related biases has been questioned. For instance, Fox et al. (2001) discussed that the prime display time that has been applied in most dot probe studies (i.e., 500ms) allows the participants to shift their attention between the competing stimuli. Therefore, it is not clear whether the faster detection of the probe appearing in the location of the threat prime stimulus is due to a difficulty to disengage from the stimulus, or because the stimuli are prioritised when orienting of attention.

Fox et al. used a modified version of the visual cueing task to differentiate the orienting and disengagement effects, and argued that their results suggested the disengagement effect. Only after that, the dot probe task was also adapted to address this differentiation (Koster, et al., 2004; Salemink, et al., 2007). These dot probe studies concluded that the threat related biases were due to the disengagement effect, although the previous studies using the dot probe paradigm (e.g., Bradley, et al., 1998) had interpreted their findings as fast orientation to threat stimuli. Based on these results, Koster et al. (2004) argued that disengagement may have been the underlying mechanism involved in, at least part of, the previous dot probe studies' findings. It is worth noting that both effects are theoretically justifiable. The fast attentional orientation means being vigilant for the possible sources of danger in the environment, and slow disengagement has been interpreted as a subtle cognitive variant of the freezing reflex that is observed in animals in response to an imminent danger in their surroundings (Fox, et al., 2001). Nevertheless, the variant of the dot probe task used by Field (2006c, 2006a) does not differentiate the two potential attentional bias mechanisms.

As seen above, the dot probe task's problem in registering attention is partly due to its limitation in presenting the stimuli. To obtain a better reflection of attention in its time course, the prime display time has been varied in some dot probe studies (e.g., 500ms and 1250ms in Bradley, et al., 1998). Although this manipulation is an

improvement, it is still not optimal, and as Garner, Mogg, and Bradley (2006a) pointed out, even with this method, the continuous attention course is broken down into discrete time points. To have a continuous registration of attention, eye tracking methodology has been used with the dot probe task (e.g., Calvo & Avero, 2005). However, this measure is bound to the specific structure of the task (i.e., displaying a pair of stimuli which are replaced by a probe). According to Bradley, Mogg, and Millar (2000), the use of eye tracking methodology with this paradigm may not be practically optimal, as in many times during the task, participants respond to the probe without looking at the primes. The final and perhaps the most important limitation of this task is the serious doubts that have been raised about the reliability of the dot probe paradigm in examining threat related attentional biases (Schmukle, 2005). Therefore, as discussed in the previous chapters, using eye tracking methodology with the visual search paradigm can be considered as the best available option for measuring threat related attentional biases. High internal consistency and retest reliability has been found for the eye tracking methodology in measuring visual attentional biases (In-Albon & Schneider, 2010).

As reviewed in the previous chapters, visual search studies using eye-tracking have supported the attentional prioritisation of threat related stimuli which include a range of stimuli such as threatening facial expressions, fear-relevant animals, pointing guns, people wielding knife and so on. This research has also documented some visual scanpaths patterns such as the hypervigilance-avoidance, and hyperscanning-avoidance. The first pattern has been reported in the visual search studies of anxiety related attentional biases in highly anxious and social phobic individuals (e.g., Calvo & Avero, 2005; Rohner, 2002), and in spider fearful individuals who were shown scenes or image matrices containing spider images (e.g., Pflugshaupt, et al., 2005; Hermans, et al., 1999; Rinck, et al., 2005). The hyperscanning-avoidance which is similar to the first pattern, has been reported by Horley et al. (2004) in social phobic individuals. Horley et al. found that these individuals avoid fixating on feature areas in angry faces, and scan extensively non-feature areas. It has been argued (e.g., Bradley, et al., 1998) that such attentional patterns may have some important pathological consequences and clinical implications: detailed scanning for threat results in increased detection of such stimuli, and the subsequent avoidance prevents learning that the stimulus is harmless, and prevents habituation. It is also possible that the attentional biases acquired through receiving threat information are associated with such attentional deployment patterns.

To briefly summarise the discussions so far, it has been found (Field, 2006a, 2006b) that attentional biases towards novel animals can be induced in children, however, the induced biases have been examined by the dot probe task. It has been argued that this task is not an optimal measure of attentional bias for its several shortcomings: dividing the continuous course of attention into discrete time points, limitations in the use of eye movement recording, and possible lack of reliability. The eye-tracked visual search method, on the other hand, is considered to be the best current option for testing threat related attentional biases. This was the method used in the experiments of the present chapter to examine the acquisition of threat related attentional biases, and the visual attentional deployment patterns associated with the biases.

In these experiments, first threat information about a novel animal was given to induce fear of, and attentional bias towards, the novel animal. Then the acquisition of fear was tested by measuring the increase in self-reported fear of the novel animal, and acquisition of threat related attentional bias was examined using two variants of the visual search paradigm. In the first search task, interference effect of threat stimuli, and in the second task, the efficient detection of threat stimuli, were measured to examine the induced attentional biases. Based on the previous research results, it was predicted that listening to threat information about the novel animal would lead to a significant increase in self-reported fear of the animal, and to exhibiting visual attentional bias towards the animal displayed by both RT and eye movement indices.

The first hypothesis, therefore, was that receiving threat information would increase fear of the novel animal about which threat information is given. The second hypothesis was that an attentional bias towards the threat animal would be acquired and would be manifested in participants' manual RTs, and the third hypothesis was that the acquired attentional bias would also be manifested in eye movement indices and visual attentional scanpaths. Similar eye movement indices as the ones measured in the previous experiment were recorded to test threat related attentional biases and visual scanpaths.

3.2. Experiment 1

The primary purpose of this experiment was to examine whether a newly feared animal could involuntarily distract participants from their search for a different target in

a stimulus array. Such an interference effect has been found in other studies, such as Miltner et al. (2004), Rinck et al. (2005), Lipp and Waters (2007), Lipp (2006, Experiment 2), and Gerdes et al. (2008). It might be the case that the interference effect caused by threat stimuli is stronger than the effect of biased attention allocation to the stimuli in demonstrating threat-related attentional biases. For instance, in Miltner et al.'s study, only the distraction effect of fear-relevant animal images, but not the speeded detection of these stimuli was found. Similarly, such interference effect was found in all the visual search tasks that were employed in Rinck et al.'s study, including the target search, category search and odd-one-out search tasks, whereas the speeded detection of the stimuli was found only in the odd-one-out task but not in the target and category search tasks. For this reason, a visual search task which aimed to measure the interference effect of threat stimuli was employed for the current experiment. The threat information animal was considered as the distractor in this search task. It was predicted that the distractor's interference effect will be reflected in retarded RTs, and in delayed first fixations on the target image, when the distractor image is displayed in the trials' stimulus arrays. Other overt attention deployment indices – such as the first fixation duration, dwell time, fixation count, and whether or not the distractors' images attract uninstructed saccades - were also examined. The purpose of measuring these indices was to test whether the newly feared stimuli (threat information animals which were displayed as distractors) also attracted overt visual attention, and to examine the possible threat related scanpaths patterns when encountering the stimuli.

3.2.1. Method

3.2.1.1. Participants

Forty-three children were invited to the experiment room. One 6-year-old girl did not complete the FBQ, because she did not understand the written instructions and the experimenter's explanations and did not want to continue. Another participant, a 7-year-old girl, could not complete the visual search task, and asked to stop doing the test. The final sample who completed both the FBQ and visual search task consisted of 21 girls and 20 boys between 6 and 10 years old ($M = 7.78$, $SD = 1.31$). They were randomly assigned to two groups: one of the groups listened to threat information about the cuscus, and were given no information about the quokka, whereas the other group were

given threat information about the quokka, but no information about the cuscus (see materials below).

3.2.1.2. Materials

Fear Belief Questionnaire (FBQ). A brief form of the FBQ constructed by Field and Lawson (2003) was employed. The original subscales of the questionnaire include cuscus, quokka and quoll, and each subscale consists of 7 statements about one of the animals and some situations in which the animal is involved (Appendix G). These statements are repeated for the other two animals in the other two subscales. The statements presentation is fully randomised, and the questionnaire begins with two practice statements. The participants are asked to endorse each statement on a 5-point Likert scale including 0 = No, not at all; 1 = No, not really; 2 = Don't know/neither; 3 = Yes, probably; 4 = Yes, definitely. Several statements are positive and have to be reversed-scored. Based on this way of scoring, higher marks indicate stronger fear beliefs about the animals. In the current experiment, only two subscales of the original test, that is, cuscus and quokka subscales, were used. Cronbach's α of the subscales were .70 (cuscus subscale) and .78 (quokka subscale) before the information, and .93 (cuscus subscale) and .86 (quokka subscale) after the information, which indicate the acceptable reliability of the subscales. As reported by Field (2006c), similar values have been found in other studies using the subscales, including $\alpha = .82, .74, .70, .74$ (Cuscus subscale); $.78, .69, .71, .68$ (Quokka subscale) before receiving the information, and $\alpha = .98, .90, .87, .87$ (Cuscus subscale); and $.98, .93, .87, .84$ (Quokka subscale) after receiving the information.

Negative story. A short story was presented to the children that contained negative and threat information about one of the marsupials (Appendix B). Depending on the condition to which each child was assigned, the name of the marsupial in the story was changed.

Visual search task. The task used in this experiment relied on the possible interference effect of the threat animal in detecting a fear irrelevant target in a visual stimulus array (e.g., Miltner et al., 2004). Based on this design threat and control animals (cuscus and quokka) pictures were presented in matrices along with fillers and target pictures. The target picture was a famous Australian marsupial, a kangaroo, and filler pictures belonged to other unfamiliar Australian marsupial species (including quoll, possum, wombat, bilby, bandicoot, antechinus, bettong, quendo, dunnart, kowari, potoroo,

kangaroo rat, pedemelon, numbat, sugar glider, and tree kangaroo). The stimuli matrices consisted of 3×3 grids, each grid location contained a picture of the whole body of one of the animals (see Appendix I for some examples). The images were coloured, centrally aligned in the grid, and with natural backgrounds. They were taken from various websites and modified by the Fireworks™ to create uniform size and dimensions. The images luminance was measured using a Konica Minolta LS110 luminance meter, and the original collection of the marsupials images had luminance specifications with $\text{Min} = 5.56\text{csm}$, $\text{Max} = 34.96\text{csm}$, $M = 16.48\text{csm}$, and $SD = 5.56\text{csm}$. The pictures with very high or very low luminance (below 11 and above 28csm) were excluded from use in the matrices. In a few cases, where there were not enough high quality pictures to replace the high or low luminance pictures, the pictures' light and brightness were manipulated using Fireworks™ to modify the luminance. The pictures used in the matrices were not significantly different in terms of luminance across different categories of stimuli, namely, the target (kangaroo), distractor (cuscus and quokka), and filler (various marsupial species) stimuli.

The selected images were used to make six types of stimuli matrices: (1) matrices with the target picture in one of the grid locations, the threat animal picture in another grid location, and the filler pictures in the remaining 7 locations; (2) matrices with the target picture in one of the grid locations, the control animal picture in another grid location, and the filler animal pictures in the remaining 7 locations; (3) matrices with the target picture in one of the grid locations, and the filler pictures in the remaining 8 locations; (4) matrices with the threat animal picture in one of the grid locations, and the filler animal pictures in the remaining 8 locations; (5) matrices with the control animal picture in one of the grid locations, and the filler animal pictures in the remaining 8 locations; and (6) matrices with filler animal pictures in all 9 grid locations.

Matrices were constructed by putting one of the target images in each one of the target present matrices (types 1, 2, and 3 above). The target images were placed in all grid locations apart from the central one (because this is where participants fixated at the beginning of each trial). Therefore, each target present condition consisted of 8 matrices in which a target image was presented in one of the 8 grid locations excluding the central grid. In the next step, one distractor image was allocated to each one of the distractor present matrices (Type 1, 2, 4, and 5). Again, the distractor images were not presented in the central grid locations, and were allocated to each of the remaining 8 grid locations once. Therefore, each distractor present condition consisted of 8 matrices

in which a distractor image was presented in one of the 8 grid locations excluding the central grid. For measuring attentional bias due to the interference effect of threat stimulus (negative information animal) image, the matrices types 1 and 2 in which both the target and distractors are presented are essential. For a more detailed analysis of a possible distracting effect, the proximity of the target and distractor images in the matrices were also manipulated, and for this purpose two separate sets of matrices were made: in the first set, the distractor stimulus (either the threat or the control animal) was in the grid location adjacent to the target picture; and in the second set, the distractor picture was further away from the target image (i.e., with one grid position separating the distractor from the target). After putting the target and distractor images in both sets of matrices, the matrices were then completed by randomly allocating the filler images to their remaining grid locations. This procedure resulted in 96 matrices comprising two sets of six conditions each, with 8 trials in each condition, and 8 trials were also added to the beginning of the task as practice trials.

In each set of the matrices, 6 exemplar images of the target stimulus (kangaroo), 4 exemplar images of each of the threat and control stimuli (cuscus and quokka) and various numbers of the different filler stimuli (different species of marsupials) were used, and it was ensured that each one of the images was not used more than 4 times and less than 3 times in each set. The practice trials consisted of 4 matrices of Condition 3, and 4 matrices of Condition 6. The matrices for these trials were made by selecting randomly 4 target images and 68 filler images, each one of which were then used once in the practice trial matrices.

3.2.1.3. Apparatus

The FBQ, the negative story, and the visual search task were all run on a Toshiba Satellite Pro A120 laptop. As in previous studies (e.g., Field & Lawson, 2003) the FBQ was presented as a computerised questionnaire, and the negative story as a computerised sound file. Both of these components were presented in an integrated session (pre-information FBQ, information reading, and post-information FBQ), which was programmed using Visual Basic.net by Prof. Andy Field. Programming the visual search task, and recording eye movements and RTs were done using similar software and devices as employed in the previous experiment under the supervision of Dr. Samuel Hutton.

3.2.1.4. Procedure

Children were tested independently in a quiet room that had a large double glazed window into the assembly/sport hall of the school. No disturbing noise came into the room when the school children had activities in the hall. Each child was given a brief explanation of the experiment and its procedure, what was expected of them, and their right to stop doing the test at any time. In the experiment session, first they answered the FBQ by specifying their answer to each question by clicking on on-screen buttons. With each question of the FBQ, one named image of the unfamiliar animal in question was also displayed. The four images which were used in the visual search task were displayed with the questions, one for each question in a random order. The questions in this test were also presented randomly. After answering the baseline FBQ, a screen appeared informing the participating children that they would now hear some information about the animals, and then the negative information was played to them through earphones from a pre-recorded MP3 file. The file was voiced by a female in her mid 20s, and the participants were told that the speaker was a teacher. Whilst the story was being read, a photograph of an adult female, which depicted an "average" female face aged mid-20s (see Field & Lawson, 2003, for more explanations), was presented on the left side of the screen, alongside a picture of the animal about which the information was given on the right side of the screen. The participants completed the FBQ again after they heard the story.

Next, the visual search task was administered, employing a similar procedure as the previous experiment. In the search task, the participants were asked to press the right button on the controller if they saw a kangaroo amongst other animals, and the left button if there was no kangaroo in the image. The participants began with the 8 practice trials, and were asked whether the practice trials were enough and they could start the experiment (called as "game"), or whether they needed more practice. They then answered the first 48 trials of the task-part, before having a break, and completing the last 48 trials. All participants, regardless of test completion, were offered a t-shirt as a present for their participation, and all of them, except a female participant who had actually completed the test, accepted the offer. The activity sheets (Appendix C) were used for debriefing the participants, which was done after all the participating children in the school had taken part in the experiment.

3.2.2. Results

3.2.2.1. Self-reported FBQ Results

Figure 3.1 shows the mean fear beliefs of the two animals before and after listening to the threat information about one of the animals. These were as follows: the mean fear beliefs for no information animal in baseline measurement was 2.20 ($SD = 0.80$), the mean fear beliefs for threat information animal in baseline measurement was 2.18 ($SD = 0.79$), the mean fear beliefs for no information animal in post-test measurement was 2.34 ($SD = 0.89$), and the mean fear beliefs for threat information animal in post-test measurement was 3.59 ($SD = 0.57$).

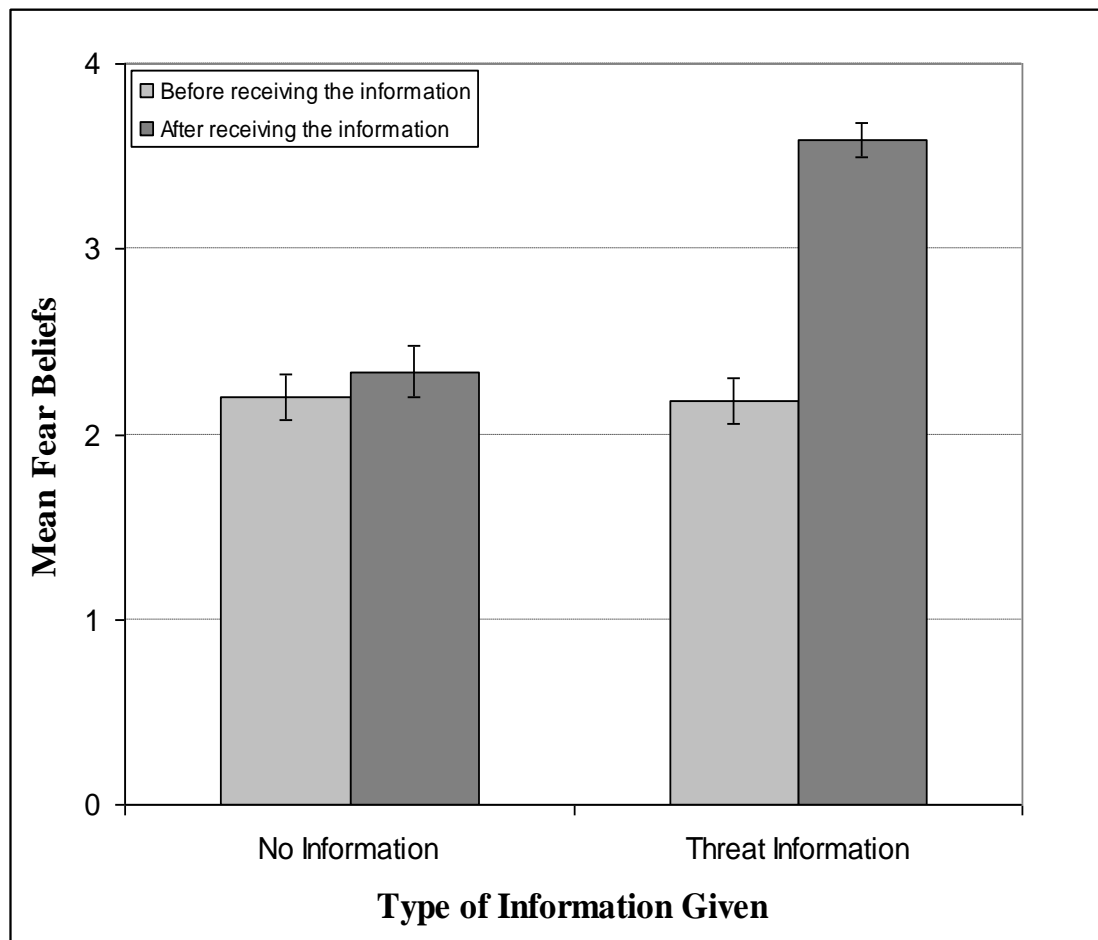


Figure 3.1. Graph showing mean fear beliefs (and their standard errors) in the baseline and post-test measurements for no information and threat information groups.

A 2 (type of information: threat vs. none) \times 2 (time: before vs. after information) repeated measure analysis of variance revealed significant effects of time, $F(1, 40) =$

80.86, $p < .0001$; information, $F(1, 40) = 31.79$, $p < .0001$; and most importantly, the interaction of information \times time, $F(1, 40) = 53.41$, $p < .0001$, which indicates that the change in fear beliefs in the post-test depended on the type of information given.

To break down the interaction effect, the pre- and post-test FBQ means were compared using four t -tests. The first test shows that there was not any significant difference between the mean fear beliefs for the control and threat animals in baseline measurement, $t(40) = 0.13$, $p > .05$. In post-test measurement, the mean fear beliefs of the animal about which no information was given was not significantly different from its mean in pre-test, $t(40) = -1.18$, $p > .05$. However, the increase in the mean fear beliefs of the threat information animal in post-test was highly significant, $t(40) = -11.04$, $p < .0001$, which resulted in a significant difference between the mean fear beliefs of the control and threat information animal in post-test, $t(40) = 8.73$, $p < .0001$. These results indicate that a significant increase in fear beliefs occurred after receiving threat information, and the effect was specific to receiving threat information, that is, it occurred only for the animal about which threat information was given.

3.2.2.2. RT data

The participants' RTs were slowest to decide whether the target was present or absent in stimulus arrays in which a distractor animal image was displayed. The mean RTs of the all trials condition (i.e., including both target present and target absent trials) were as follows: the mean RTs of the trials with threat-related animal distractor was 3313.85 ($SD = 1560.49$); the mean RTs of the trials with no information animal distractor was 3272.57 ($SD = 1591.58$); and the mean RTs of trials without any distractor was 3239.86 ($SD = 1546.09$). Skewness of RT values was 1.23, and log-transformation improved the values' skewness (skew = -0.15), therefore the log-transformed values were used in the regression analysis. Table 3.1 shows the sequential models fitted to the data. The final model was a random intercept model, with fixed slopes for trial type and target presence. In this model, covariance structure was explicitly modelled, but heteroscedasticity in the trial type predictor was not modelled.

Table 3.2 shows the parameters of this final model. In this regression analysis, the trials with the threat information animal distractor was the baseline category for the trial type (i.e., the threat information) effect. There was a significant effect of trial type in predicting RTs, suggesting that RT to decide whether the target is present in a stimulus

array is significantly slower when a threat information animal image is also present in the array. Both linear and quadratic trends of trial sequence, and the interaction effect of trial sequence and trial types were also significant suggesting that RTs varied over trials and this variation also depended on the type of the trial to which a participant responds. Thus, the analysis above shows that presence of a threat information animal distractor significantly delayed the time to decide about the presence of a target. The interaction of target presence and trial type variables was not significant, indicating that the effect of trial type did not differ in the target present and target absent conditions; therefore, no follow-up analysis in each one of the conditions was conducted.

Table 3.1. Summary of the model selection process for the RTs to decide about the presence of the targets in all trials.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	-2182.38		
Trial type × Target presence	-1492.79	1379.19	< .0001
Heteroscedasticity (Trial type)	-1492.30	0.98	<i>ns</i>
Trial	-1489.62	6.34	< .05
Covariance structure (Trial)	-1432.78	113.67	< .0001
Trial × Target presence	-1429.50	6.56	< .05
Trial × Trial type	-1426.19	6.63	< .05
Trial × Target presence × Trial type	-1425.46	1.45	<i>ns</i>
Trial type (random slopes across participants)	Failed to converge		

Table 3.2. Summary of the regression model predicting RTs to decide about the presence of the target, with threat information distractor trials as the baseline category.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	7.8907	0.1042	3602	75.72	< .0001
Trial type – No information distractor	0.1967	0.0662	3602	2.97	< .01
Trial type – No distractor	0.1608	0.0655	3602	2.46	< .05
Target presence	-0.1435	0.0962	3602	-1.49	<i>ns</i>
Trial sequence – Linear trend	0.3702	0.1060	3602	3.49	< .001
Trial sequence – Quadratic trend	0.3093	0.1016	3602	3.04	< .01
Trial type – No information distractor × trial sequence	-0.0024	0.0008	3602	-3	< .01
Trial type – No distractor × trial sequence	-0.0017	0.0008	3602	-2.21	< .05

3.2.2.3. Time of the first fixation on the target

In the analyses of the eye movement data, three types of interest areas were defined for the three types of stimuli (target, distractors, and fillers) which covered the whole image in all trials. In other words, the eye movement data of the whole stimulus arrays were broken down into the different types of stimuli. Depending on the analysis, the data recorded for particular interest areas were retained and the remaining data, which were not relevant to the analysis, were filtered out.

In the case of the analysis of the first eye movements index, the first fixation times on the targets were compared in different trials, including the trials with threat information distractor, the trials with no information distractor, and the trials in which no distractor was displayed; therefore, only target present trials were included in the analysis.

The means of the first fixation times on targets in different conditions were as follows: for the trials with threat distractor 1449.72 ($SD = 1067.11$), for the trials with no information animal distractor 1417.99 ($SD = 1043$), and for the trials without any distractor 1399.68 ($SD = 966.72$). Skewness of the first fixation time values was 1.75, and log-transformation improved the values' skewness ($skew = -0.64$), therefore log-transformed values were used in the regression analysis. Table 3.3 shows the sequential models fitted to the data.

Table 3.3. Summary of the model selection process for the first fixation time on the targets.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	-2034.10		
Trial type	-2034.07	0.06	<i>ns</i>
Heteroscedasticity (Trial type)	-2030.82	6.51	< .05
Trial	-2026.57	8.50	< .05
Covariance structure (Trial)	-2025.61	1.93	<i>ns</i>
Trial \times Trial type	-2022.27	8.61	.0716
Trial type (random slopes across participants)	-2022.27	-	-

The final model was a random intercept but fixed slope model, in which heteroscedasticity of the trial type predictor was modelled. The parameters of this final model are presented in Table 3.4.

Table 3.4. Summary of the regression model predicting the first fixations on targets, with the threat information distractor trials as the baseline category.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	6.9507	0.0837	1768	83.0255	< .0001
Trial type – No information distractor	-0.2718	0.1071	1768	2.5380	< .05
Trial type – No distractor	-0.2624	0.1148	1768	2.2856	< .05
Trial sequence – Linear trend	-0.0912	0.1164	1768	0.7832	<i>ns</i>
Trial sequence – Quadratic trend	-0.0429	0.1002	1768	0.4283	<i>ns</i>

There was a significant effect of trial type in predicting the first fixation time on targets, suggesting that the first fixation times on targets were significantly slower when a threat information animal image was also present in the stimulus array.

3.2.2.4. Time of the first fixation on distractors

In this part of the analysis (i.e., the analyses of this eye movement index' and the next 4 indices' data), attention deployment to the threat information and no information distractors are compared. Therefore, for these analyses, only the eye movement data pertaining to the distractors' interest areas of each trial's stimulus array were retained in the analyses, and the data of the non-distractor's interest areas were filtered out; therefore, the trials with no distractor were also excluded from the analysis.

The mean of the first-fixation times on the threat distractors was 1313.04 ($SD = 988.09$); and on the no information animal distractors was 1288.58 ($SD = 1000.39$). Skewness of the first fixation times values was 1.55, and log-transformation improved the values' skewness (skew = -0.26), therefore, log-transformed values were used in the analysis. Table 3.5 shows the sequential models fitted to the data.

The final model was a random intercept model with fixed slopes for the trial type and target presence variables, in which covariance structure of the trial variable was explicitly modelled. Table 3.6 shows the parameters of this final model. There was no significant effect of trial type in predicting the first fixation times on distractors, suggesting that overall the first fixation times on the threat information and on the no information animals' images were not significantly different. The effect of target presence variable was significant suggesting that first fixation time on the distractor was significantly faster in target present trials.

Table 3.5. Summary of the model selection process for the first fixation times on distractors.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	−2211.93		
Trial type × Target presence	−2190.28	43.29	< .0001
Heteroscedasticity (Trial type)	−2189.92	0.73	<i>ns</i>
Covariance structure (Trial)	−2184.83	10.91	< .05
Trial	−2179.92	9.80	< .01
Trial × Trial type	−2178.61	2.62	<i>ns</i>
Trial × Target presence	−2173.97	11.90	< .001
Trial × Trial type × Target presence	−2173.39	1.17	<i>ns</i>
Trial type (random slopes across participants)	−2173.60	0.74	<i>ns</i>

Table 3.6. Summary of the regression model predicting first fixation times on distractors, with the threat information distractor as the baseline category.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	6.7746	0.0424	1826	159.75	< .0001
Target presence	0.2140	0.05120	1826	4.18	< .0001
Trial type	−0.0684	0.0558	1826	−1.23	<i>ns</i>
Target presence × Trial type	0.0529	0.0723	1826	0.73	<i>ns</i>
Trial sequence – Linear trend	−5.0028	1.2582	1826	−3.98	< .001
Trial sequence – Quadratic trend	−2.5341	1.2335	1826	−2.0543	< .05

3.2.2.5. Duration of the first fixation on distractors

The mean of the first fixation durations on the threat distractors was 200.00 ($SD = 82.73$); and on the no information animal distractors was 200.08 ($SD = 82.54$). Skewness of the first fixation duration values was 1.49, and log-transformation improved the values' skewness (skew = −0.79), therefore, the log-transformed values were used in the regression. Table 3.7 shows the sequential models fitted to the data.

The final model was a random intercept but fixed slopes model, in which neither heteroscedasticity in the trial type predictor, nor covariance structure for the trial predictor was modelled. Table 3.8 shows the parameters of this final model.

Table 3.7. The model selection process for the duration of the first fixations on distractors.

Model	Log-Likelihood	<i>LR</i>	<i>P</i>
Baseline	-1033.84		
Trial type \times Target presence	-1033.23	1.20	<i>ns</i>
Heteroscedasticity (Trial type)	-1031.64	3.20	<i>ns</i>
Covariance structure (Trial)	-1031.38	3.73	<i>ns</i>
Trial	-1032.33	1.82	<i>ns</i>
Trial \times Trial type	-1032.84	0.80	<i>ns</i>
Trial \times Target presence	-1031.87	2.74	<i>ns</i>
Trial \times Trial type \times Target presence	-1031.52	3.44	<i>ns</i>
Trial type (random slopes across participants)	Failed to converge		

Table 3.8. Summary of the regression model predicting the duration of first fixations on distractors, with the threat information distractor as the baseline category.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	5.21	0.0294	1837	177.31	< .0001
Target presence	0.0228	0.0275	1837	0.830	<i>ns</i>
Trial type – No information distractor	0.0224	0.0299	1837	0.7477	<i>ns</i>
Target presence \times Trial type	-0.0420	0.0388	1837	-1.0812	<i>ns</i>

Trial type had no significant effect in predicting first fixation durations on distractors, suggesting that the first fixation durations on the threat information and on the no information animals' images were not significantly different.

3.2.2.6. Number of fixations on distractors

The mean of fixation counts on the threat distractors was 1.2691 ($SD = 1.1981$); and on the no information distractors was 1.2210 ($SD = 1.1911$). Skewness of the fixations count values was 1.61, and log-transformation improved the values' skewness (skew = 0.07), therefore, log-transformed values were used in the analysis. Table 3.9 shows the sequential models fitted to the data.

The final model was a random intercept and fixed slopes model, in which the covariance structure of the trial type predictor was explicitly modelled. Table 3.10 shows the parameters of this final model.

Table 3.9. Summary of the model selection process for the number of the fixations on distractors.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	−1905.59		
Trial type × Target presence	−1738.32	334.55	<.0001
Heteroscedasticity (Trial type)	−1738.28	0.07	<i>ns</i>
Covariance structure (Trial)	−1724.34	27.95	<.0001
Trial	−1720.69	7.30	<.01
Trial × Trial type	−1720.58	0.22	<i>ns</i>
Trial × Target presence	−1717.85	5.68	<i>ns</i>
Trial × Trial type × Target presence	−1719.90	1.58	<i>ns</i>
Trial type (random slopes across participants)	−1720.60	0.18	<i>ns</i>

Table 3.10. Summary of the regression model predicting the number of fixations on distractors, with the threat information distractor as the baseline category.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	0.5157	0.0249	2578	20.74	<.0001
Target presence	0.3506	0.0256	2578	13.70	<.0001
Trial type	-0.0119	0.0256	2578	-0.47	<i>ns</i>
Trial sequence – Linear trend	-1.3496	0.4638	2578	-2.91	<.05
Trial sequence – Quadratic trend	0.4726	0.4648	2578	1.02	<i>ns</i>
Target presence × Trial type	-0.0177	0.0362	2578	-0.49	<i>ns</i>

There was no significant effect of trial type in predicting number of fixations on distractors, suggesting that number of fixations on the threat information and on the no information animals' images were not significantly different. There was also a significant effect of target presence on fixation counts, suggesting that the number of fixations on distractors was significantly lower in target present trials.

3.2.2.7. Dwell time on distractors

The mean of dwell times on the threat information distractor was 247.61 (*SD* = 254.09), and on the no information distractor was 241.49 (*SD* = 267.21). Skewness of the dwell time values was 2.77, and log-transformation improved the values' skewness (skew = −0.84), therefore, log-transformed values were used in the regression. Table 3.11 shows the sequential models fitted to the data.

Table 3.11. Summary of the model selection process for dwell times on distractors.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	−6215.05		
Trial type × Target presence	−6069.02	292.07	<.0001
Heteroscedasticity (Trial type)	−6068.92	0.20	<i>ns</i>
Covariance structure (Trial)	−6059.36	19.32	<.0001
Trial	−6057.45	3.82	<i>ns</i>
Trial × Trial type	−6058.69	1.35	<i>ns</i>
Trial × Target presence	−6058.91	0.91	<i>ns</i>
Trial × Trial type × Target presence	−6059.35	0.02	<i>ns</i>
Trial type (random slopes across participants)	−6059.04	0.65	<i>ns</i>

The final model was a random intercept and fixed slopes model, in which covariance structures in the trial type predictor was explicitly modelled. Table 3.12 shows the parameters of this final model.

Table 3.12. Summary of the regression model predicting dwell time on distractors, with the threat information distractor as the baseline category.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	3.1805	0.1135	2580	28.03	< .0001
Target presence	1.8036	0.1327	2580	13.59	< .0001
Trial type	0.0784	0.1327	2580	0.59	<i>ns</i>
Target presence × Trial type	−0.2460	0.1874	2580	−1.31	<i>ns</i>

There was no significant effect of trial type in predicting dwell times on distractors, suggesting that dwell times on the threat information and on the no information animals' images were not significantly different. There was, however, a significant effect of target presence on dwell times, suggesting that dwell times on distractors was significantly longer in target present trials.

3.2.2.8. Percentage of dwell time on distractors

The mean of the percentages of dwell times on the threat distractors was 0.0849 (*SD* = 0.0737), and on the no information animal distractors was 0.0853 (*SD* = 0.0793). Skewness of the dwell time percentage values was 1.13, and log-transformation

improved the values' skewness (skew = 0.81), therefore, log-transformed values were used in the regression. Table 3.13 shows the sequential models fitted to the data.

The final model was a random intercept and fixed slopes model, in which heteroscedasticity in the trial type predictor was explicitly modelled, but no covariance structure was modelled for the trial predictor. Table 3.14 shows the parameters of this final model.

There was no significant effect of trial type in predicting the percentages of dwell time on distractors, suggesting that the percentages of dwell time on the threat information and on the no information animals' images were not significantly different. There was a significant effect of target presence on dwell time percentages, suggesting that the percentage of dwell times on distractors was significantly higher in target present trials.

Table 3.13 Summary of the model selection process for the number of the fixations on distractors.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	3316.35		
Trial type × Target presence	3360.89	89.09	<.0001
Heteroscedasticity (Trial type)	3363.33	4.87	< .05
Covariance structure (Trial)	3363.36	0.06	<i>ns</i>
Trial	3363.84	1.01	<i>ns</i>
Trial × Trial type	3363.99	1.32	<i>ns</i>
Trial × Target presence	3363.74	0.82	<i>ns</i>
Trial × Trial type × Target presence	3363.64	0.62	<i>ns</i>
Trial type (random slopes across participants)	3364.00	1.36	<i>ns</i>

Table 3.14. Summary of the regression model predicting the percentage of dwell time on distractors, with the threat information distractor as the baseline category.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	0.0660	0.0027	2580	24.02	< .0001
Target presence	0.0265	0.0036	2580	7.39	< .0001
Trial type	0.0018	0.0037	2580	0.49	<i>ns</i>
Target presence × Trial type	-0.0034	0.0052	2580	-0.64	<i>ns</i>

3.2.2.9. The first fixated image

In one third of the experiment trials, both target and distractor were displayed in the same stimulus arrays. In this part of the analysis, it is examined on which one of these two images in the arrays participants fixated first, and whether threat-related distractor images were fixated before the target more often than no information distractor images were fixated before the target. In the threat information distractor trials, targets were fixated before distractors 301 times, and distractors were fixated before targets 341 times. In the no information distractor trials, targets were fixated before distractors 376 times, and distractors were fixated before targets 272 times. In 14 trials of the threat distractor condition and 8 trials of the no information distractor condition, none of the target or distractor images were fixated. These trials were excluded from the analysis. The counts of the first fixated image were compared in a multilevel regression analysis to examine whether threat information has a significant effect on the differences in the counts. Table 3.15 shows the sequential models fitted to the data.

Table 3.15. Summary of the model selection process for the counts of the first fixated image (whether the target or the distractor is fixated first in the stimulus array).

	Log-Likelihood	χ^2	<i>p</i>
Baseline	-891.25		
Trial type	-883.21	16.07	<.0001
Trial	-875.56	15.31	<.0001
Trial \times Trial type	-875.49	0.14	<i>ns</i>
Trial type (random slopes across participants)	-875.49	-	-

The final model was a random intercept and fixed slopes model. Table 3.16 shows the parameters of this final model.

Table 3.16. Summary of the regression model predicting the stimulus that was first fixated in the stimulus arrays.

	<i>b</i>	<i>SE b</i>	<i>z</i>	<i>p</i>
Intercept	-0.4691	0.1271	-3.69	< .0001
Trial type	0.3882	0.1143	3.39	< .0001
Trial sequence	0.0093	0.0024	3.95	< .0001

There was a significant effect of trial type in predicting the first fixated image, suggesting that whether the target or distractor gets fixated first in a trial's stimulus array significantly depended on the type of information given.

As mentioned above, fixating first on distractors occurs more often when distractor is a threat-related one. On the other hand, when distractor is a no information one, targets are fixated first more often. To examine the significance of the differences, a standardised residual analysis was conducted. The results are presented in the contingency table below (Table 3.17).

Table 3.17. Contingency table of the counts of the images that are fixated first in threat and no information distractor conditions.

		Trial Type		
		Threat information	No information	Total
		distractor	distractor	
The first fixated image	Count	341	272	613
	Distractor Expected count	304.8	308.2	613
	Standardised residuals	2.1	-2.1	
	Count	301	377	678
	Target Expected count	337.2	340.8	678
	Standardised residuals	-2	2	
	Count	642	649	1291
	Total Expected count	642	649	1291

As seen in this table, all the differences between expected and observed values have z values higher than 1.96, suggesting that these differences are significant, that is, in the threat-relevant condition trials, distractors were fixated first significantly more than targets, and in the no information condition trials, targets were fixated first significantly more than distractors.

3.2.2.10. Summary of the results

RTs to decide whether the target is present or absent in the stimulus array was delayed in the trials in which a threat information animal was also displayed in the array. The delay caused by the presence of threat information distractor in RTs was a general effect, and did not interact with target presence; in other words, RT delays were not different in target present and target absent trials. The first fixations on the target were also delayed when a threat information distractor was present in the array.

Although these findings demonstrate the interference effect of threat information animal images, little evidence of differential attention allocation to the threat information and no information animal images was found. The visual attention deployment to the distractor images was compared in terms of five indices, including the time of the first fixation, duration of the first fixation, number of fixations, dwell time, and dwell time percentage, and none of the differences was significant. There was, however, a difference between the threat information and no information distractor images in terms of attracting uninstructed saccades. In the trials where both target and distractor images were present, the threat information distractor was fixated before the target significantly more frequently than the no information distractor was fixated before the target. This suggests that when searching for the target in stimulus arrays, the threat information distractors attracted more uninstructed saccades than the no information distractors.

3.2.3. Discussion

Listening to threat information about a novel animal led to increases in fear beliefs about the animal, which suggests the acquisition of fear of the novel animals due to receiving threat information. This finding supports the first hypothesis, and replicates the results of several studies by Field and his colleagues (for a review see Field & Purkis, *in press*).

Inducing the fear of the unfamiliar animal also led to acquiring attentional bias towards this newly feared stimulus. This attentional bias effect was concluded from three indices results. Firstly, the presence of a picture of the threat animal as a distractor in a stimulus array significantly delayed the decision times as to whether an irrelevant target is present in the array. Secondly, the presence of the threat distractor significantly delayed the time of the first fixation on the target in the stimulus array. Thirdly, in the trials where both target and distractors were present, the first fixation significantly more frequently landed on the threat distractor than the target, and significantly less frequently landed on the neutral distractor than the target. These are in line with the findings of Field (Field, 2006c, 2006a) who showed the acquisition of attentional bias to newly feared animals using the dot probe paradigm. Therefore, the current experiment replicates Field's findings with a more reliable paradigm.

The interference effect found in the RT data is consistent with several visual search studies (e.g., Miltner et al., 2004; Rinck et al., 2005; Lipp and Waters, 2007; Lipp

,2006, Experiment 2; Gerdes et al., 2008), which have all, despite using different designs, found such an interference effect caused by threat stimuli. In the current experiment, the delay in RTs caused by the presence of threat distractors was a general decision time effect, that is, it did not interact with the target presence variable and was found similarly in both target present and target absent trials.

The significant effects found for the two eye movement indices (mentioned above) confirm the interference effect caused by the threat stimulus. Unlike the RT effect, these eye movement effects were based only on target present trials, and display the effect of threat distractors in overt attentional deployment processes. The interference effect, however, was the only overt attention deployment effect, and no other evidence was found for differential attention allocation to threat distractors relative to neutral (no information) distractors. In other words, no significant difference was found between the threat and neutral distractors in terms of eye movement variables, including first fixation time, first fixation duration, fixation count, dwell time, and dwell time percentage; therefore, there is no evidence to suggest that attention allocation to newly feared animals was different from the allocation of attention to the non-feared distractors. Thus, no inference can be made in terms of the underlying mechanisms of the attentional bias effect (e.g., whether the bias effect is due to the fast engagement or the late disengagement mechanisms), and in terms of the attentional deployment patterns (such as hypervigilance-avoidance pattern). The eye movement results are, therefore, only partly supportive of the third hypothesis. On one hand, they indicate that the newly feared stimulus was distracting, because it caused delays in the first fixation times on targets, and attracted the first fixations before the fixations landed on the target. But on the other hand, comparing the scanpaths of the newly feared and control distractors provides little evidence for the existence of different patterns of attentional deployment to the two types of stimuli.

One part of the eye movement indices findings, showing the higher frequency of fixations on the threat distractor before the target, is consistent with Miltner et al.'s (2004) findings which indicate that spider phobics fixate significantly more on spider images before fixating on a fear-irrelevant target image. The other part of the eye movement results pertaining the lack of any evidence of preferential attention allocation to threat distractors is in contrast with the previous eye-tracked visual search studies such as Rinck et al. (2005) Gerdes et al. (2008), Herman et al. (1999) and Pflugshaupt et al. (2005, 2007). In all of these studies some type of preferential visual attentional

deployment to threat stimulus was found. For instance, Rinck et al. (2005) and Gerdes et al. (2008) found more prolonged gaze durations on threat distractors relative to non-threat distractors. Such effects were not found in the current experiment. It should be noted that such inconsistencies in eye movement results are not uncommon, for instance, in Gerdes et al.'s study threat related distractor images were not fixated more than the neutral distractor images, but were fixated for longer durations. However, in the present experiment, unlike Gerdes et al.'s study, none of the eye movement indices showed a preferential attention allocation to the threat stimuli. It might be the case that visual attentional patterns for pre-established fear objects, such as spiders, are different from the patterns for newly feared animals, and this might be the reason for the discrepancies between the results of the present and previous studies. Examining the pattern of attention deployment to newly acquired fear stimuli using other visual search designs will be helpful in answering this question. This will be pursued in the next experiment of this chapter.

In general, both RT and eye movements results of this experiment indicated an attentional bias towards the threat stimulus. This stimulus was an unfamiliar animal whose fear was induced by threat related information. One of the main aims of the present study was to disentangle the underlying visual attentional mechanisms of the attentional bias effect towards the newly feared animals. Although it did not find any evidence pertaining to the mechanisms, this experiment showed that the unfamiliar and newly feared animals can interfere with participants' RTs and eye movement responses.

3.3. Experiment 2

Attentional bias towards newly feared animals was found in the previous experiment: the animal's image distracted the participants when they were searching for a non-feared animal in image matrices. Although this finding is worthwhile, as discussed before, the expected differential allocation of attention toward the threat and neutral distractors was not found in the previous experiment. Moreover, the stimuli presentation sets that tapped the attentional bias effect, i.e., matrices made up of square animal images, is different from the visual scenes which participants experience in everyday life. In the second experiment, naturalistic scenes, which possibly have more ecological validity than matrices, were employed as the visual search images. In this task, the threat and control stimuli were hidden in the jungle scenes, and the participants

were instructed to search for the stimuli in the images. The jungle scenes were similar to what was described as the habitat of the threat animal in the FBQ paradigm, and the degree of difficulty of finding the hidden animal varied across the scenes, but for almost all the images, the participants needed to search the image actively to detect the target. The task aimed to tap a different type of threat related attentional bias, which is involved in detecting the threat, rather than being distracted by the threat. Therefore, it was predicted to find the direct attention deployment effects which were not found in the first experiment. This task was first used in Field et al.'s (2009) study without the use of the eye tracking methodology. It was shown in this study that RTs were significantly faster when finding the threat information animal than the no information animal. A relatively similar task was used by Pflugshaupt et al. (2005) in which spider images were added to everyday life scenes, and spider anxious and control participants were instructed to search for the spiders. They found a pattern of fast orientation/late avoidance in the spider fearful participants when attending to spider images. In the present study, similar to Pflugshaupt et al.'s study, the participants' eye movements were also recorded to examine the overt attention deployment patterns when searching the hidden threat stimuli in visual scenes.

3.3.1. Method

3.3.1.1. Participants

Forty-nine children participated in the experiment and completed the FBQ. One 6-year-old boy could not understand the visual search task instructions and failed to respond to several trials within the allowed response time. He subsequently asked to terminate the experiment session. One 8-year-old girl did not feel comfortable, and was not willing to continue the experiment after answering the FBQ. These two participants, therefore, did not complete the visual search task, and the final sample consisted of 25 girls and 22 boys between 6 and 11 years old ($M = 7.21$, $SD = 1.23$). Similar to Experiment 1, these participants were randomly assigned to two groups. One of the groups listened to threat information about cuscus, and were given no information about quokka, whereas the other group were given threat information about the quokka, but no information about the cuscus.

Materials, apparatus and procedure of this experiment were similar to the ones used in Experiment 1 except for the visual search task, which is described below.

3.3.1.2. Materials

Reliability of the FBQ subscales. Cronbach's α of the subscales were .72 (cuscus subscale) and .70 (quokka subscale) before the information; and .85 (cuscus subscale), and .90 (quokka subscale) after the information.

The Visual search task. This task consisted of 108 trials, 54 of which were target present and 54 were target absent. In target present trials, there was a cuscus or a quokka hiding in a naturalistic jungle image, and in target absent trials, there was no animal in the image (see Appendix I for an example). The trials were presented in two blocks: in one of the blocks cuscus was the target and in the other one quokka was the target. Each block consisted of 27 target present trials, and 27 target absent trials; therefore, in one of the blocks, cuscus images were hidden in 27 images and the other 27 images were target absent, and in the other block quokka images were hidden in 27 images and the other 27 images were target absent. The order of block presentation was counterbalanced across participants, so that half the participants responded to the cuscus block first and the other half responded to the quokka block first.

The images were created by a professional graphic designer using Photoshop™. Nine different naturalistic jungle images were used to make the target present and target absent images. In the target present trials, each one of these exemplar images were used three times for each one of the target animals to make 27 target present images. In each of these three images the target animal was hidden in a different place, resulting in unique sets of target present images. These images were manipulated so that target detection difficulty varied among them. The 9 exemplar jungle images were repeated three times for each block (and 6 times in total) to make the target absent images.

3.3.2. Results

3.3.2.1. Self-reported FBQ results

Figure 3.2 shows the mean fear beliefs of the two animals before and after listening to the threat information about one of the animals. These were as follows: mean fear beliefs for the no information animal in baseline measurement was 1.83 ($SD = 0.85$), for the threat information in baseline measurement was 1.85 ($SD = 0.77$), for the no information animal in post-test measurement was 2.10 ($SD = 0.87$), and for the threat information animal in post-test measurement was 3.27 ($SD = 0.82$). A 2 (type of information: threat vs. none) \times 2 (time: before vs. after information) repeated measure

analysis of variance revealed significant effects of time, $F(1, 46) = 104.69, p < .0001$; information, $F(1, 46) = 31.16, p < .0001$; and most importantly, the interaction of information \times time, $F(1, 46) = 40.44, p < .0001$, which indicates that the change in fear beliefs in the post-test depended on the type of information given.

To further examine these results, the pre- and post-test FBQ means were compared using four t -tests. The first test shows that there was not any significant difference between the mean fear beliefs for the control and threat animals in the pre-test, $t(46) = -0.18, p > .05$. The mean fear beliefs of the threat animal increased significantly in the post-test measurement as compared to their scores in the baseline measurement, $t(46) = -10.71, p < .0001$.

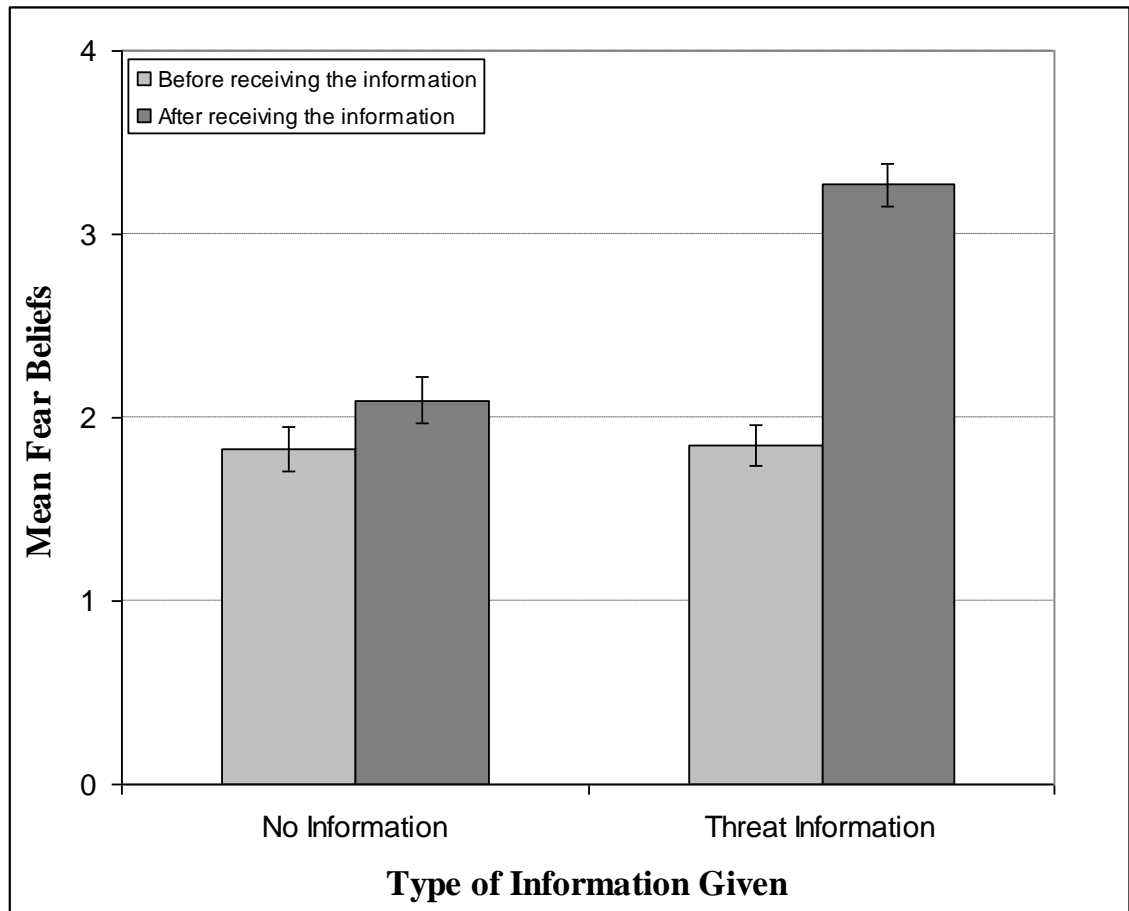


Figure 3. 2. Graph showing mean fear beliefs (and their standard errors) in the baseline and post-test measurements for no information and threat information groups.

There was also an unexpected significant increase in the mean fear beliefs of control animal from baseline to post-test, $t(46) = -2.38$, $p < .05$, which might have been due to generalising the fear acquired for the threat animal to the control animal. In the post-test, however, the mean fear beliefs of the threat information animal was significantly higher than the means for the no information animal, $t(46) = -7.00$, $p < .0001$. Therefore, it was concluded that even in the case of acquiring some fear towards the control animal, significantly more fear is induced for the threat animal, which will possibly be reflected in the participants' visual attentional patterns and any potential attentional bias effect that they might show.

3.3.2.2. RT data

The mean RTs in both target present and target absent trials were as follows: 5720.99 ($SD = 4943.63$) for the trials with threat-related target; and 5711.54 ($SD = 4108.56$) for the trials with no information animal target. Skewness of the RT values was 3.53, and log-transformation notably improved the values' skewness (skew = 0.0043), therefore log-transformed values were used in the regression analysis. Table 3.18 shows the sequential models fitted to the data.

Table 3.18. Summary of the model selection process for RTs to decide about the presence of the target in all trials.

Model	Log-Likelihood	LR	P
Baseline	-3879.44		
Trial type	-3878.11	2.67	<i>ns</i>
Target presence	-3118.95	1518.32	<.0001
Trial type \times Target presence	-3114.04	9.81	<.01
Heteroscedasticity (Trial type)	-3113.20	1.68	<i>ns</i>
Covariance structure (Trial)	-2997.31	233.45	<.0001
Trial	-2944.44	105.75	<.0001
Trial \times Trial type	-2944.28	0.32	<i>ns</i>
Trial \times Target presence	-2943.02	2.84	<i>ns</i>
Trial \times Trial type \times Target presence	-2942.96	2.96	<i>ns</i>
Trial type (random slopes across participants)	-2929.68	29.52	<.0001

The final model was a random intercept model, with fixed and random slopes for trial type, and fixed slopes for target presence and the interaction of trial type and target

presence. In this model, both heteroscedasticity in the trial type predictor and covariance structure of trials were explicitly modelled. Table 3.19 shows the parameters of this final model.

Table 3.19. Summary of the regression model predicting the RTs of all trials.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	8.7482	0.0424	3931	206.38	< .0001
Trial type	-0.0183	0.0383	3931	-0.48	<i>ns</i>
Target presence	0.6702	0.0220	3931	30.43	< .0001
Trial type × Target presence	-0.0920	0.0312	3931	-2.95	< .01
Trial sequence – Linear trend	-9.1876	0.8864	3931	-10.36	< .0001
Trial sequence – Quadratic trend	2.2893	0.6032	3931	3.79	< .001

No significant effect was found for trial type in predicting RTs, suggesting that RTs to decide whether the target is present in the jungle images were not significantly different for threat and control animals across both target present and target absent images. However the effect of target presence was significant, suggesting that RTs were significantly faster in target present trials. Also there was a significant interaction of trial type and target presence variables suggesting that RTs to decide about the presence of targets significantly varied in target present and target absent conditions. Therefore, follow up analyses were conducted to examine the interaction effect.

The mean RTs in target present trials were as follows: 3569.03 (*SD* = 3265.73) for the trials with threat-related target, and 3999.86 (*SD* = 3471.24) for the trials with no information animal target. Skewness of the RT values was 4.26, and log-transformation improved the values' skewness (*skew* = 0.56), therefore log-transformed values were used in the analysis. Table 3.20 shows the sequential models fitted to the data.

The final model was a random intercept model, with fixed and random slopes for trial type, in which heteroscedasticity in the trial type predictor and covariance structure of trial predictor were explicitly modelled. Table 3.21 shows the parameters of this final model.

The effect of trial type in predicting RTs was significant, suggesting that RTs were significantly faster when detecting the threat-related targets relative to the control ones.

Table 3.20. Summary of the model selection process for RTs to detect the targets.

Model	Log-Likelihood	LR	<i>p</i>
Baseline	-1528.28		
Trial type	-1522.75	11.06	< .0001
Heteroscedasticity (Trial type)	-1519.50	6.49	< .05
Covariance structure (Trial)	-1492.71	53.58	< .0001
Trial	-1476.32	32.79	< .0001
Trial × Trial type	-1475.58	1.47	<i>ns</i>
Trial type (random slopes across participants)	-1470.09	12.46	< .0001

Table 3.21. Summary of the regression model predicting the RTs to detect the targets.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	7.9856	0.0503	1648	158.61	< .0001
Trial type	0.1341	0.0456	1648	2.94	< .01
Trial sequence – Linear trend	-5.0916	0.8158	1648	-6.24	< .0001
Trial sequence – Quadratic trend	1.5126	0.6181	1648	2.45	< .05

The mean RTs of the target absent trials were as follows: 7338.28 (*SD* = 5358.05) for the threat condition; and 6969.26 (*SD* = 4087.23) for the control condition. Skewness of the RT values was 3.78, and log-transformation improved the values' skewness (skew= 0.40), therefore log-transformed values were used in the analysis. Table 3.22 shows the sequential models fitted to the data.

The final model was a random intercept model with a random slope for trial type, in which heteroscedasticity in the trial type predictor and covariance structure of trial predictor were explicitly modelled. Table 3.23 shows the parameters of this final model.

Table 3.22 Summary of the model selection process for RTs in the target absent trials.

Model	Log-Likelihood	LR	<i>p</i>
Baseline	-1407.81		
Trial type	-1407.57	0.46	<i>ns</i>
Heteroscedasticity (Trial type)	-1405.15	4.85	< .05
Covariance structure (Trial)	-1270.34	269.62	< .0001
Trial	-1218.36	103.96	< .0001
Trial × Trial type	-1217.63	1.47	<i>ns</i>
Trial type (random slopes across participants)	-1205.18	26.36	< .0001

Table 3.23. Summary of the regression model predicting the RTs in target absent trials.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	8.7200	0.0473	2235	184.48	< .0001
Trial type	0.0217	0.0366	2235	0.59	<i>ns</i>
Trial sequence – Linear trend	-6.6111	0.7146	2235	-9.25	< .0001
Trial sequence – Quadratic trend	1.8935	0.5115	2235	3.70	< .001

The effect of trial type in predicting RTs was not significant, suggesting that the RTs when realising the absence of the animal images in the jungle scenes were not significantly different in threat and control conditions.

3.3.2.3. Time of the first fixation on the target

The means of the first fixation time on targets were as follows: 2066.07 (*SD* = 3300.33) for the threat-related targets; and 2106.18 (*SD* = 2320.23) for the no information animal targets. Skewness of the first fixation time values was 8.78, and log-transformation improved the values skewness (skew = 0.25), therefore log-transformed values were used in the analysis. Table 3.24 shows the sequential models fitted to the data.

Table 3.24. Summary of the model selection process for the times of the first fixation on targets.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	-2436.26		
Trial type	-2435.47	1.58	<i>ns</i>
Heteroscedasticity (Trial type)	-2435.45	0.04	<i>ns</i>
Covariance structure (Trial)	-2435.41	0.10	<i>ns</i>
Trial	-2430.87	9.19	< .05
Trial × Trial type	-2430.86	0.02	<i>ns</i>
Trial type (random slopes across participants)	-2425.68	10.39	< .01

The final model was a random intercept model with a random slope for trial type, in which neither covariance structure of trial predictor nor heteroscedasticity of trial type predictor were modelled. Table 3.25 shows the parameters of this final model.

Table 3.25. Summary of the regression model predicting the first fixation time on threat-related and non-threat targets.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	7.1687	0.0414	1786	172.98	< .0001
Trial type	0.0748	0.0564	1786	1.33	<i>ns</i>
Trial sequence – Linear trend	-2.3635	1.1614	1786	-2.04	< .05
Trial sequence – Quadratic trend	-0.5042	0.8930	1786	-0.56	<i>ns</i>

The effect of trial type in predicting first fixation time was not significant, suggesting that (in contrary to the RT data) fixating the threat animal in the jungle scenes was not significantly faster than fixating the control animal in the scenes.

3.3.2.4. Duration of the first fixation on the target

The means of first fixation duration on the targets were as follows: 354.95 (*SD* = 309.68) for the threat-related targets; and 352.24 (*SD* = 297.77) for the no information animal targets. Table 3.26 shows the sequential models fitted to the data.

Table 3.26 Summary of the model selection process for the durations of the first fixation on targets.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	-1779.70		
Trial type	-1779.66	0.07	<i>ns</i>
Heteroscedasticity (Trial type)	-1779.59	0.14	<i>ns</i>
Covariance structure (Trial)	-1778.94	1.45	<i>ns</i>
Trial	-1778.38	2.57	<i>ns</i>
Trial × Trial type	-1779.45	0.43	<i>ns</i>
Trial type (random slopes across participants)	-1778.40	2.52	<i>ns</i>

The final model was a random intercept model in which neither covariance structure of trial predictor nor heteroscedasticity of trial type predictor were modelled. Table 3.27 shows the parameters of this final model.

The effect of trial type in predicting the first fixation durations was not significant, suggesting that the durations of the first fixations on the threat-related targets and on the control targets were not different.

Table 3.27. Summary of the regression model predicting the duration of the first fixation on threat-related and non-threat targets.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	5.6307	0.0317	1806	177.81	< .0001
Trial type	0.0077	0.0291	1806	0.27	<i>ns</i>

3.3.2.5. Number of fixations on the target

The targets fixation count means were as follows: 1.91 ($SD = 1.93$) for the threat-related targets; and 2.1 ($SD = 2.37$) for the no information animal targets. Skewness of the dwell time values was 3.06, and log-transformation improved the values' skewness (skew= 0.01); therefore, log-transformed values were used in the regression analysis. Table 3.28 shows the sequential models fitted to the data.

Table 3.28. Summary of the model selection process for the number of fixations on targets.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	-2472.09		
Trial type	-2469.86	4.47	< .05
Heteroscedasticity (Trial type)	-2469.33	1.06	<i>ns</i>
Covariance structure (Trial)	-2467.48	4.76	< .05
Trial	-2461.26	12.44	< .01
Trial \times Trial type	-2459.69	3.15	<i>ns</i>
Trial type (random slopes across participants)	-2448.01	26.50	<.0001

The final model was a random intercept model with a fixed slope for trial type, in which covariance structure of trial predictor was explicitly modelled. Table 3.29 shows the parameters of this final model.

Table 3.29. Summary of the regression model predicting the number of fixations on threat-related and non-threat targets.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	0.8627	0.0265	2476	32.59	< .0001
Trial type	0.0701	0.0385	2476	1.82	.0689
Trial sequence – Linear trend	-3.2119	0.8999	2476	-3.57	< .01
Trial sequence – Quadratic trend	-0.7910	0.5845	2476	-1.35	<i>ns</i>

The effect of trial type in predicting the number of fixations on the target was marginally significant, suggesting that there was a trend in fixating less frequently on threat animal images than the control animal images.

3.3.2.6. Dwell time on targets

The means of the dwell times on the targets were as follows: 1195.52 ($SD = 949.70$) for the threat-related targets; and 1279.27 ($SD = 1248.71$) for the no information animal targets. Skewness of the dwell time values was 5.19, and log-transformation improved the values' skewness ($skew = -0.33$), therefore log-transformed values were used in the analysis. Table 3.30 shows the sequential models fitted to the data.

Table 3.30. Summary of the model selection process for dwell times on targets.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	−2018.01		
Trial type	−2017.70	0.62	<i>ns</i>
Heteroscedasticity (Trial type)	−2014.55	6.30	< .05
Covariance structure (Trial)	−2014.49	0.11	<i>ns</i>
Trial	−2012.50	4.09	<i>ns</i>
Trial × Trial type	−2012.69	3.73	<i>ns</i>
Trial type (random slopes across participants)	−2012.58	3.93	<i>ns</i>

The final model was a random intercept and fixed slope model in which heteroscedasticity of the trial type predictor was explicitly modelled. Table 3.31 shows the parameters of this final model.

Table 3.31. Summary of the regression model predicting the dwell time on targets.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	6.8511	0.0381	1805	179.61	< .0001
Trial type	0.0260	0.0330	1805	0.79	<i>ns</i>

The effect of trial type in predicting dwell time on the target was not significant, suggesting that there was no significant difference between the time of dwelling on the threat animal and the control animal image.

3.3.2.7. Percentage of dwell time on targets

The means of the percentages of dwell time on the targets were as follows: 0.2980 ($SD = 0.2642$) for the threat-related targets; and 0.3100 ($SD = 0.2678$) for the no information animal targets. Skewness of the dwell time percentage values was 0.33, but log-transformation did not improve the values' skewness (skew = -1.52), therefore the non-transformed values were used in the analysis. Table 3.32 shows the sequential models fitted to the data.

Table 3.32. Summary of the model selection process for the percentage of dwell times on targets.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	-198.64		
Trial type	-198.12	1.05	<i>ns</i>
Heteroscedasticity (Trial type)	-198.02	0.19	<i>ns</i>
Covariance structure (Trial)	-194.76	6.71	< .01
Trial	-194.66	0.20	<i>ns</i>
Trial \times Trial type	-194.72	0.09	<i>ns</i>
Trial type (random slopes across participants)	-185.19	19.14	< .0001

The final model was a random intercept model with a random slope for trial type, in which covariance structure of the trial variable was explicitly modelled. Table 3.33 shows the parameters of this final model.

Table 3.33. Summary of the regression model predicting the percentage of dwell time on targets.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	0.2981	0.0125	2478	23.79	< .0001
Trial type	0.0103	0.0142	2478	0.73	<i>ns</i>

The effect of trial type in predicting the percentage of dwell time on target was not significant, suggesting that the percentage of time dwelt on the threat animal image is not significantly different from the time spent on the control animal image.

3.3.3. Discussion

Similar to the previous experiment, the results of the FBQ paradigm indicated that fear beliefs significantly increased after receiving threat information. It was therefore concluded that fear of the novel animal was acquired and the first hypothesis of this experiment is supported. The RT data showed that the participants detected the unfamiliar animal about which they received threat information significantly faster than the control animal in the jungle images. These faster detection times indicate an attentional bias towards the threat animal. Therefore our second hypothesis is also supported, and it can be concluded that inducing fear of the novel animal has led to acquiring attentional bias towards it. This finding is consistent with several studies which have shown faster RTs to detect a threat related target compared with non-threat targets, whether the threat target was a feared animal such as a snake or a spider (e.g., Öhman, Flykt, and Lundqvist, 2000), a threat facial expression such as an angry face (e.g., Waters and Lipp, 2008), or a potentially dangerous object such as a gun (e.g., Blanchette, 2006, Fox, Griggs, Mouchlianitis, 2007). Particularly, this finding is consistent with the studies by Field (2006c, 2006a) who, similar to this experiment, first induced fear of novel animals by employing the FBQ paradigm, then used a dot probe task to measure the attentional bias towards the threat animals, and found faster reaction times to detect the probe replacing the threat animals as compared to the non-threat ones. Moreover, the RT results of the current experiment replicates the study by Field et al. (2009) who found the effect using the same visual search task. .

The main purpose of the current experiment was to explore the visual attentional deployment patterns when searching in naturalistic scenes for the newly acquired threat stimuli. However, there was little difference between the eye movement responses to the feared and control stimuli, and little evidence was found for differential attention allocation patterns towards threat and non-threat targets. For only one eye movement index - fixation counts - a marginally significant effect was found indicating that children fixated less on threat relative to non-threat animal images. There was no significant difference between the threat and control targets in terms of the first fixation time, first fixation duration, dwell time and dwell time percentage. Therefore, no inference can be made with regard to the underlying mechanisms of threat related attentional biases (e.g., orientation/disengagement effects), with regard to the eye

movement responses to threat stimuli (e.g., freezing response), or with regard to threat related visual scanpaths patterns (e.g., hypervigilance-avoidance).

Nevertheless, fewer fixations on threat targets along with non-different dwell times on threat and control targets can mean fewer but longer fixations on threat targets relative to non-threat ones. This seems to be the only visual scanpath pattern that can be drawn from the eye movement findings. This pattern is not similar to the ones reported in previous eye tracking studies examining threat-related visual attention. The hypervigilance/avoidance pattern is the pattern which has been reported frequently in the past research (e.g., Hermans, Vansteenwegen, & Eelen, 1999; Pflugshaupt et al., 2005; Rinck and Becker, 2006) in spider phobics when encountering spider images. Although the stimuli and participants of these studies are different from the ones employed in the current experiment, there were some specific similarities between the design of the current experiment and the one of Pflugshaupt et al.'s study. In that study, spider images were added to everyday scenes of a house (such as bathroom and sitting room) and spider phobic and non-phobic participants were instructed to find and count the spiders displayed in the scenes. Due to these similarities, the occurrence of a similar hypervigilance-avoidance pattern would be expected, but this was not found in the current experiment. As discussed in the previous experiment, the failure to find the visual scanpaths patterns observed in previous studies might be due to the difference between the biases displayed towards a newly acquired fear stimulus and a pre-established fear or phobia stimulus. It might be the case that threat-related visual attentional patterns such as fast orientation and fast avoidance, which have been found in phobic individuals (e.g., Pflugshaupt et al., 2005; Rinck and Becker, 2006), are specific to intense fears and phobias, and are not found in mild and moderate fears acquired by listening to threat information.

A possible explanation for some of the differences between the current and previous studies' findings can be the specifications of the current experiment's search task. In the present experiment search task, the targets were not easily recognisable from the background images, and an effortful search was required to detect them. A fast orientation effect, for instance, might occur only when the target is easily recognisable, but not when the target is hidden in the scenes and its detection needs careful inspection. Detection of such hidden targets, relative to the easily recognisable targets, might be involved more substantially in processing the specifications of the target and background images to differentiate the target from its background, which in turn might

weaken the fast orientation effect. This specification of the search task can also explain the unexpected lack of association between the RT and fixation time results. The hidden targets in this task meant that the differentiation and recognition of the targets could take some time after they were fixated. In some cases, the detection occurred after several visits to the target interest area. Thus, the association between the first fixation on the targets and RTs to detect them in these trials was weakened, which in sum, might have resulted in different results for the two indices. It should be noted that it is highly unlikely that the different results for the two indices, which suggest low covariation of the two indices, are due to covert attentional mechanism (i.e., manually responding the trials without fixating on them; see e.g., Posner, 1980; Bradley et al., 2000), as it was necessary in almost all trials to fixate the target interest area to be able to detect the hidden animal and answer the trial correctly.

The significantly faster RTs to detect the threat information animal images in the naturalistic jungle scenes indicates that although the threat targets were not fixated any faster than the control targets, they were finally detected significantly faster than the control targets. In other words, the acquired fear of novel stimuli did not facilitate gaze orientation to the feared stimuli, but facilitated differentiating and recognising the feared stimuli from their backgrounds. This may mean that threat stimuli are processed more efficiently than the non-threat ones.

3.4. General Discussion

In the first experiment, images of a newly feared animal (the animal about which children received threat information) interfered with detecting an irrelevant neutral target. In the matrices where a threat animal image was present, manual RTs to decide whether the target was present or absent, and the time of the first fixation on the target, were both significantly delayed. Moreover, the threat distractors attracted significantly more uninstructed saccades relative to the control distractors. This was shown in the matrices where both target and distractor images were present. In these stimulus arrays, when the distractor was the threat animal image, the first fixation landed significantly more on the distractor than on its relevant target; and when the distractor was the non-threat animal image, the first fixation landed significantly more on the target than on the control distractor. These findings indicate an attentional bias towards newly acquired fear stimuli in the form of an interference effect. However, the attentional bias effect

was limited only to the interference effect. In other words, no difference in eye movement indices was found between the threat and non-threat images. Therefore, attention deployment effects which have been reported in the previous research on threat-related stimuli (such as fast orientation, prolonged dwell time, freezing response, and the hypervigilance-avoidance scanpaths pattern) were not found in this experiment with the newly acquired fear stimuli.

The attentional bias towards the newly feared stimuli was also found in the second experiment. Similar to the first experiment, the bias was indicated by the participants' RTs, as they were significantly faster when detecting a threat target relative to a non-threat one; and similar to the first experiment, little difference was found between the feared and non-feared animals when they were compared directly in terms of the eye movement indices. Therefore, in the second experiment, the effect of acquiring fear on attentional responses was demonstrated only in a faster differentiation of threat targets from their backgrounds comparing with the differentiation of non-threat targets from their relevant backgrounds. This is consistent with the proposal of the efficient processing of threat stimuli, which, as discussed in the first chapter, has been considered to have neurological bases, and has been supported by studies such as the attentional bias ones.

Although both experiments of this chapter found threat related attentional bias effects demonstrated by RTs, in these experiments little evidence was found for differential overt visual attention allocation towards threat and non-threat stimuli. Failure to replicate the eye movement findings in the second experiment can partly be attributed to the specific design of the experiment's search task. In this task, the threat and control targets were hidden in the visual scenes, unlike the previous attentional bias studies in which stimulus arrays consisted of easily recognisable images. Nonetheless, the search task used in the first experiment is not too different from the tasks used in the previous studies, and could have tapped the predicted overt attentional deployment responses, but the scanpaths patterns were not found in the first experiment either. This raises the possibility of another explanation, which is the differences between the participants and the threat stimuli used in this study and the previous ones.

The stimuli used in the current experiments were two Australian marsupials, which were compared in terms of attentional bias responses. In the previous studies, however, the non-threat stimuli which were compared against the threat stimuli included a more diverse range of images, such as different animals (e.g., horse, cat, fish, butterfly,

beetle), plants (e.g., flower, mushroom), and every day scenes. As reviewed in Chapter 1, some researchers (e.g., Lipp, 2006; Soares, Esteves, & Flykt, 2009) have argued that the homogeneity of the stimuli used in the stimulus arrays influences attentional bias responses. It might be the case that the similarity of the threat and control stimuli used in the current experiments might have had an effect in limiting the eye movement responses to the stimuli. Nonetheless, this similarity did not affect some of the main predicted effects in both current experiments, such as the distraction effect found in the first experiment, and efficient threat detection effect found in the second experiment.

The other main difference between the current experiments and the aforementioned studies is in their samples. In most of the previous studies in which different eye movement results have been found for threat and non-threat animal pictures, the participants were phobic or fearful individuals with pre-established fears. Whereas in the present experiments, the stimuli were novel, and the fear of the novel stimuli were just acquired by the participants. Theoretically, we do not expect acquiring intense fears by listening to threat information in one session. Therefore, the levels of fears in the participants of the previous studies and this study might have been different. It might be the case that such visual scanpaths patterns as hypervigilance-avoidance are specific to pre-established and intense fear stimuli, and do not emerge when encountering newly acquired, mild fear stimuli.

Because the experiments of this chapter were designed for children as young as 6-year-olds, we were cautious about the run time of the experiments, and attempted to keep the time as short as possible. Thus, only the tasks which were considered necessary were included in the experiments, and the components which would have been informative but were not crucial were not included. For instance, although administering a trait anxiety scale would have provided us with some useful data about the interaction of anxiety predisposition and the acquisition of fear and attentional bias, such a scale was not used.

Moreover, due to the time limitations, the visual search tasks consisted of only two information conditions, that is, the threat, and the no information conditions. In other words, the existence of attentional bias to threat stimuli was concluded by comparing the threat and the no information animals in terms of attention deployment indices. By adding another information condition, for instance, a positive, or a neutral information animal, the mere effect of receiving information on displaying attentional bias towards novel animals could have also been examined. In other words, a conclusion pertaining

the existence of attentional bias towards threat information animal would have been more precise if another condition was included in the tasks in which some neutral or positive information, equivalent to the threat information, was given to children about a third type of novel animals. If the children showed attentional bias to threat information stimulus, but not to the no information and positive information stimuli, then it could have been concluded confidently that acquiring attentional bias results from receiving threat information, and other types of information would not caused such a bias. A positive (or neutral) information condition, however, was not included in the current studies because of the aforementioned time constraints.

Although it cannot be definitely concluded from the results of these two experiments that the threat content of the information is the cause of the bias effects and not the mere effect of receiving information, attentional biases specific to threat information stimuli have been reported in the past research. As mentioned before, Field (2006a, 2006c) included threat, positive, and no information conditions in the employed attentional bias tasks, but found no attentional bias towards the positive information stimuli in these studies. Therefore, it is likely that such an attentional bias specific to threat information stimuli would have also been found in the present experiments, if a positive or neutral information condition was added to the experiments.

To further investigate the visual scanpahts patterns associated with the attentional biases towards newly feared stimuli, it will be beneficial to conduct another visual search study in which the images are easily recognisable, and the instruction is to search for a target or a deviant image. Such a study will inform us about the attentional patterns during visual scanning of easily recognisable threat targets. It was not possible for the researcher of the present study to conduct the proposed research, due to difficulties to recruit child participants. Instead, the research of the acquisition of fear by receiving threat related information and its possible effects on the visual attentional patterns continued in adult samples. This will be the topic of the next chapter of this thesis.

Chapter 4: The Effect of Threat Information on Attentional Bias toward Fear-relevant Animals

4.1. Introduction

As mentioned in the discussion part of the previous chapter, we faced a major problem in recruiting child participants for the studies of this thesis, therefore, to complete the studies on time, it was decided to change the target population of the studies to adults. The change in the age range of the samples also led to an important methodological change, that is, changing the studies' threat stimuli. While in the child studies, the aim was to induce fear and attentional bias of novel stimuli; in the adult studies, the aim was to induce (or enhance) fear and attentional bias of fear-relevant animals. The reason for this change in the studies' threat stimuli was the assumption of novelty made for the child studies which could not be realistic for the adult samples. More specifically, it could be assumed that Australian marsupials were novel for the samples used in the previous chapter's studies (i.e., British primary school children), but for the adult samples which were intended to be tested in the experiments of this chapter (i.e., university students), such animals might not be novel. It was likely that these participants had prior knowledge about the animals, and might have realised that the threat information was not true. This would have caused a major problem in the studies because believing the threat information is crucial for inducing fear and attentional bias. Thus, instead of novel animals, threat information was given about fear-relevant animals in the experiments of the present chapter. Fear-relevant animals were selected because it was assumed that threat information would be most believable for such kind of stimuli for the adult samples. One of the most commonly feared animals, that is, snakes, was used as threat stimuli in these experiments.

Humans frequently report being afraid of snakes and spiders. This has been documented in epidemiological studies of fear in both adult and child populations (as reviewed in Chapter 1). While there is consensus on the prevalence of snakes and spiders fears, the origin of the fears is debated. The main fear genesis theories can be divided into three approaches in terms of the existence of an evolutionary basis for snakes and spiders' fears. The first approach, the non-associative approach (e.g.,

Poulton & Menzies, 2002) proposes the existence of an inborn fear of poisonous animals in humans due to the human's evolutionary history. According to this theory the innate fear is activated in the first encounter with the animals, but if the person continues to experience safe encounters with them, the fear gradually habituates, and subsides. The second approach, including the preparedness theory (e.g., Seligman, 1971) and its relevant elaborations (e.g., by Mineka & Öhman, 2002a; Mineka & Zinbarg, 2006), disagrees with the notion of an inborn fear of the animals which appears in the first exposure; but contends that we learn fear of these animals more readily than fear of the fear-irrelevant stimuli. On the other end of the fear origin theories' spectrum is the equipotentiality account, according to which, there is an equal probability for all stimuli to be feared by humans, and humans do not have a special tendency to link some stimuli to danger.

The elaborations of the preparedness theory can currently be considered as the most commonly accepted accounts of fear learning. A number of studies have been conducted to compare learning the fear of fear-relevant and fear-irrelevant animals in both human and primates. Research on human adult participants using conditioning paradigms has shown that fear responses, mainly skin conductance, are learned more readily for fear-relevant animals than fear-irrelevant stimuli, and the conditioned fear of fear-relevant animals is more resistant to extinction than the fear of fear-irrelevant stimuli and the fear of ontogenetic fear stimuli (e.g., Öhman, et al., 1975; Hugdahl & Kärker, 1981). Moreover, the research found that after learning the fear of different stimuli, the images of fear-relevant animals, but not fear-irrelevant stimuli, were perceived subconsciously when the stimuli were presented in masked condition (Öhman & Soares, 1994). In other research, vicarious learning paradigms have been employed in primates and human child participants to investigate the preparedness accounts' proposals. Research on laboratory-reared monkeys showed that the monkeys learned the fear of fear-relevant stimuli, such as toy snakes and crocodiles, which were novel to them, by watching wild-reared monkeys behaving with fright towards the stimuli. The monkeys, however, failed to learn fear of fear-irrelevant stimuli, such as toy rabbits and flowers in a similar process (Cook & Mineka, 1989).

Vicarious learning research on human toddlers, on the other hand, shows that fear of both fear-relevant and fear-irrelevant stimuli can be learned by observing others' reactions to the stimuli (Dubi et al., 2007). In Dubi et al.'s study, the toddlers' baseline fear towards fear-relevant stimuli (rubber snake or spider), and fear-irrelevant stimuli

(rubber flower or mushroom) was measured, and no significant difference was found between the baseline scores. The stimuli then were paired either with negative (fear and disgust verbal and nonverbal gestures) or neutral expressions, which were displayed by the toddlers' mothers. The toddlers' fear reactions towards the toys that were paired with fear and disgust expressions significantly increased, compared to the toys that were associated with neutral expressions. The increase in fear response, however, occurred for both fear-relevant and fear-irrelevant stimuli indifferently, and no significant difference was found between the fear that was expressed by toddlers to fear-relevant and fear-irrelevant stimuli.

Similarly, in a prospective study, Gerull and Rapee (2002) investigated learning fear of fear-relevant animals through vicarious learning pathway. In this study, the toddlers' mothers displayed either negative (i.e., fear and disgust) or positive expressions to snake and spider rubber toys. The toddlers showed higher fear expressions and avoidance towards the toys which were paired with their mother's negative expressions significantly more than the toys paired with the positive expressions. In this study, however, fear-irrelevant control animal stimuli were not used, and the toddlers' baseline fear responses towards the animal stimuli were not measured, therefore, it is not clear whether the higher fear expressions that the toddlers showed to the snake and spider toys at the end was an added effect to the already existing fear, or it was a totally new effect. However, the researchers reported that they had tried to choose the scariest toys for the experiment, which implies that an initial fear of the toys was assumed.

In two more studies by Field and his colleagues (Field, et al., 2001; Askew & Field, 2007) learning fear of (assumed) fear-irrelevant stimuli through vicarious learning pathway was examined. In the first study (Field, et al., 2001), children's fear beliefs about two novel monster dolls did not change significantly before and after watching a videotape in which a female adult displayed negative expressions to one of the dolls and positive expressions to the other doll. This indicates that the children did not acquire fear of novel stimuli by observing the negative expressions. In the second experiment (Askew & Field, 2007), however, observing photos of adults displaying fearful facial expressions paired with the pictures of novel animals (i.e., Australian marsupials) significantly increased the participating children's fear responses towards the animals. In this latter experiment, therefore, fear of the novel animals was transmitted vicariously.

The other indirect pathway to fear learning, that is, the information pathway, has also been studied in the acquisition of fear of novel stimuli (monster dolls and Australian marsupials) in the studies conducted by Field and his colleagues (e.g., Field, et al., 2001; Field & Lawson, 2003). In these studies, receiving threat information led to the acquisition of fear of the stimuli about which threat information was given (see Muris & Field, 2010; Field & Purkis, in press, for reviews).

In sum, fear of both fear-relevant and fear-irrelevant stimuli can be learned through direct and indirect fear pathways, and in some studies it has been shown that fear of fear-relevant animals are acquired more readily. The preparedness to learn fear of these stimuli has been taken as evidence for the humans' prioritisation of the stimuli and situations that have been significant threats in our evolutionary history.

Attentional bias is another index of the prioritisation of fear-relevant stimuli. An abundance of research has investigated attentional bias to fear-relevant stimuli, and more specifically snakes and spiders. The research has mainly supported existence of an attentional prioritisation of fear-relevant animals' stimuli using different attentional bias paradigms: the results of visual search tasks have displayed the bias effect in both forms of fast detection of, and distraction by, fear-relevant animal images. These effects have been found in both RTs and eye movement results, and in both phobic individuals and the general populations from the very young ages (as reviewed in Chapter 1). It has been found that phobic individuals, in addition to displaying a general attentional bias towards the fear-relevant animals, display stronger attentional bias towards the animal of which they are phobic, for instance, snake phobics show a general attentional bias towards spiders, and a stronger bias towards snakes (e.g., Öhman, Flykt, et al., 2001). Moreover, some threat related visual scanpaths patterns, such as hypervigilant-avoidance pattern, have also been found in phobic people when encountering the fear-relevant stimuli, namely spider images for spider phobic individuals (e.g., Rinck & Becker, 2006).

Although the attentional bias findings mainly support the proposal that processing fear-relevant animals' stimuli is prioritised over fear-irrelevant stimuli, there are some findings inconsistent with the proposal. In some visual search studies (e.g., Lipp, et al., 2004; Purkis, Lester, & Field, 2011), attentional bias effects towards fear-irrelevant animals (e.g., horses, cats and fish) and other fear-irrelevant stimuli (e.g., TV programme characters for the programme's fans), have also been found; and in other

studies, the bias effect was displayed to both evolutionary (snakes and spiders), and ontogenetic (such as guns and knives) threat-related stimuli (e.g., Blanchette, 2006).

Attentional bias towards feared stimuli is not a fixed, innate, response: it can be acquired. It was shown in Field (2006a, 2006c) that inducing fear of novel (and presumably fear-irrelevant) animals in children by giving threat information about the animals leads to the acquisition of visual attentional bias towards the animals. This indicates how sensitive humans are in learning the possible dangers in the environment, and how responsive the cognitive system is to assimilate the new inputs, and detect the newly defined threat sources in the environment based on the inputs.

Consistent with the previous studies of learning the fear of fear-relevant animals through vicarious learning pathway, and learning the fear of novel animals through informational learning pathway, it is reasonable to predict that the fear of fear-relevant animals can also be acquired through receiving threat information. We know that among a type of fear-relevant animal, such as snakes, there are several different species: some harmless, and some dangerous and even deadly. The harmless and dangerous species can look similar, so that only the people who are familiar with the two species can differentiate them. These people presumably obtain their knowledge through information; therefore, information can make the difference to whether a species is perceived as safe or dangerous. It is possible that when we are informed that a fear-relevant species is harmless, our fear ceases, and we are better able to approach the animal.

Based on the previous studies that showed the acquisition of attentional bias towards novel animals about which threat information was given, it can be predicted that inducing fear of a fear-relevant animal through information can lead to an increase in the (assumed) pre-existing attentional bias towards the fear-relevant animal. In other words, receiving threat information about the animal can magnify our fear and vigilance for the animal in the surroundings, and this will be reflected in visual scanpaths when searching in the scenes.

The main points of the discussions in the introduction can be summarised as follows:

- Fear of novel stimuli can be learned through indirect pathways to fear, namely vicarious and informational pathways, in humans;
- Acquiring fear of the novel stimuli through indirect fear pathways is associated with acquiring attentional bias towards the stimuli;

- Fear of fear-relevant stimuli has also been learned through an indirect pathway to fear, namely vicarious learning, both in humans and primates;
- It can be predicted that fear of fear-relevant stimuli can be learned, or enhanced, through informational fear pathway in humans;
- It can be predicted that the acquisition, or enhancement, of fear of fear-relevant stimuli is associated with acquiring, or enhancing, attentional bias towards fear-relevant stimuli.

These predictions were examined in the studies of the present chapter. In these studies, threat information about one type of snake, and no information about another type were given to adult participants, and their attentional bias towards the fear-relevant animals were tested using different variants of the visual search paradigm (the paradigms are described below). In all of the variants employed, both RT and eye movements were measured to investigate both baseline attentional bias to fear-relevant stimuli and the enhancement in the bias due to receiving threat information. To measure the baseline fear-relevant attentional bias effect, attentional responses to snake stimuli were compared with the responses to fear-irrelevant stimuli, namely fish images. To measure the enhanced bias effect, attentional responses to the snake about which the participants received threat information were compared with the responses to the snake about which the participants received no information. Similar to the previous experiments, the visual attentional scanpath patterns were also investigated by examining various eye movement indices.

4.2. Experiment 1

The main aim of this experiment was to examine whether threat information can increase the interference effect of a fear-relevant animal. In this experiment, a visual search task with an interference effect design, similar to the task administered in Experiment 2 of Chapter 3, was used. In this task, the effects of the presence of a fear-relevant animal (in general), and the threat information fear-relevant animal (in particular), in detecting an unrelated fear-irrelevant target were examined. Thus, the first hypothesis was that the presence of the distractors' images (threat and no information snake images) would delay the RTs to decide whether the target is present or absent, and the delay would be longer when the distractor was the threat information

snake. The second hypothesis was that such delays would also occur in the times of the first fixation on the target. Therefore, the presence of a snake image would delay the time of the first fixation on the target, and the delay would be longer when the distractor was a threat information snake.

Although, the present visual search task was designed to examine the distraction effect of snake stimuli, differences in overt attention allocation to the two types of fear-relevant distractors, and to the fear-irrelevant stimuli used as fillers in the search tasks, were also examined. Similar to the previous experiments, the overt attention allocation indices include the first fixation time, first fixation duration, dwell time, and dwell time percentage. These data can show the possible differences in direct attention deployment to the different stimuli. The additional hypothesis, therefore, was that participants would display a general attentional bias towards snake images, and a specific bias effect towards the threat information snake stimuli, as compared to fear-irrelevant stimuli.

4.2.1. Method

4.2.1.1. Participants

Thirty adults between 20- and 44-year-old ($M = 26.43$, $SD = 6.47$) participated in the study, of which 19 were female and 11 male. The participants were recruited from the participants' pool of the Psychology School of the University of Sussex, UK. The participants were the university's students and staff. It was decided to exclude snake phobic participants from the sample in the present and next study. Based on the prediction that snake phobics display high levels of attentional bias toward snake images, and because displaying ceiling levels of attentional bias would mean that receiving threat information could not have an effect on these participants' attentional bias, this exclusion criterion was set. The exclusion criterion was, therefore, scoring 16 or more on the Snake Phobia Questionnaire (SNQ, see below). None of the participants of this experiment, however, scored at the phobia diagnostic range, and no one was excluded from the sample. The participants were randomly assigned to two groups. One of the groups were given threat information about one of the snakes (the black snake) and no information about the other snake (the brown snake), and the other half of the sample received information in the opposite order. The groups were matched in terms of gender.

4.2.1.2. Materials

The Snake Fear Questionnaire (SNAQ, Klorman, Weerts, Hastings, Melamed, & Lang, 1974) is a widely used test for measuring snake fear, and consists of 30 items, with the score range of 0-30 (Appendix H). Cronbach's α of the scale in the current experiment sample was 0.78 indicating the scale's acceptable reliability.

The Trait Anxiety Subscale of the State-Trait Anxiety Inventory Form Y (STAI-Y Spielberger, et al., 1983) is also one of the most widely used scales for measuring trait anxiety and consists of 20 items with the score range of 20-40 (Appendix H). Cronbach's α of the scale in the current experiment sample was 0.92 which shows high reliability of the scale.

The Stimuli Attitude Scale. This scale was designed to measure the participants general attitudes toward the animals whose images were used in the visual search task (i.e., snakes, amphibians, including frogs and salamanders, and fish). To respond to the scale, the participants were asked to indicate for each animal separately whether or not they were afraid of the animal, whether or not they were afraid of seeing the animal's images, and whether or not they liked seeing the animal's images, and the extent of their fear and interest. They were asked to indicate this extent by making a tick on a visual analogue scale (VAS) which was a line 10 cm long with the anchors *not at all afraid/interested* and *extremely afraid/interested*. The scale was used mainly as a quick screening device to make sure that the threat information and the images were not distressing for the participants, and to exclude the ones who might have felt uncomfortable when completing the experiment's tasks (Appendix H).

The snake life facts. A piece of information in the form of zoological life facts was given about a fake snake species, called the Pamir Viper. This included information such as physical description, natural habitat, nutritional habits, circadian course, maternal behaviours, defensive/offensive capabilities, and the snake's prevalence and the extent of contact with human. These were mainly the facts about different real snake species, which were selected from various zoological websites, and assembled to maximize the threat induction probability, and to appear as a real snake's life facts (Appendix E). The physical description of the described snake in the piece of information was adapted in accordance with the appearance of one of the two snakes whose images were used in the visual search task.

The visual search task. The design of the task used in this experiment was identical to the task that was used in Experiment 2 of Chapter 3. The target pictures in this task

were fish images, and the filler pictures were amphibian images (frogs, toads, salamanders, and newts). The distractors' images belonged to two different snake species: the Black Racer, and the California King Snake. In each of the two sets of the matrices of this task, 12 exemplar images of the target stimulus (fish), 8 exemplar images of each of the threat and control stimuli (the California King Snake, and the Black Racer Snake), and 128 exemplar images of the filler images (amphibians) were used. Therefore, the target and distractor images were used twice, and the filler images were used three times in each set (Appendix I). The luminance of the stimuli images was manipulated using similar methods as used in Experiment 2 of Chapter 3, and the pictures used in the matrices were not significantly different in terms of luminance across different categories of stimuli (targets, distractors, and fillers).

4.2.1.3. Apparatus

The snake life facts and the visual search task were both run on a Toshiba Satellite Pro A120 laptop. The two snakes life facts were presented as computerised sound files, which were recorded using a Panasonic sound recorder, and were then adapted and prepared for presentation using the Audacity® software. Programming the visual search task, and collecting the eye movement and RT data were conducted using similar software and devices as used in the previous experiments. The only exception was that a tower mounted infrared emission device and camera set (instead of the desktop set) was used to record the participants' eye movements.

4.2.1.4. Procedure

Participants were recruited by an email sent to the Psychology School's participants' pool. Not suffering from eye conditions that interfere with the eye movement recording (such as strabismus), and not having excessive fear of snakes were mentioned in the email as recruitment conditions. The participants completed the experiment individually. They were asked to read the information sheet, and sign the consent form upon arrival at the laboratory (Appendix D). They then completed the stimuli attitude scale, and their answers to the scale were reviewed by the experimenter to examine their eligibility of taking part in the experiment. There was no sign in the participants' answers to indicate that participating in the study might cause distress in them. None of the participants, therefore, was excluded from taking part in the study. The participants continued by listening the threat information sound file through

earphones. The threat information was read by a female in her late 20s, and simultaneously, four images of the snake about which the participants were given threat information were displayed on the screen. After listening to the sound file, the participants were sat at the desk on which the eye tracking devices were placed, and were asked to put their chin on the headrest of the camera tower. The chair and headrest were adjusted, and the eye tracker was calibrated through a similar procedure as the previous experiments. After the calibration, the visual search task started by an instructions page which asked the participants to press the right button if they saw a fish amongst other animals, and the left button if there was not any fish in the images matrix. The instructions were also explained verbally, and both speed and accuracy was emphasised, with a special emphasis on accuracy. Participants began with 8 practice trials, and were asked whether the practice trials were enough and they could start the experiment, or whether they needed more practice. None of the participants needed more practice trials. They then completed 48 trials, before they were asked to have a break, and continued the experiment by answering the remaining 48 trials. After completing the search task, they were asked to answer the trait anxiety questionnaire and snake fear questionnaire, and after that participants were paid for their time, and were given the debriefing forms (Appendix D). The forms include the true information (Appendix F) about the life of the snake about which the participants were given false threat information.

4.2.2. Results

4.2.2.1. Trait anxiety

The range of trait anxiety scores was between 22 and 60 ($M = 38.00$, $SD = 8.53$).

4.2.2.2. Snake phobia

The range of snake phobia scores was between 0 and 14 ($M = 5.57$, $SD = 4.01$).

4.2.2.3. RT data

The participants' RTs were slowest to decide whether the target was present or absent in a stimulus array when a distractor snake image was also displayed in the array. The mean RTs of all trials (including both target present and target absent trials) were as follows: 1790.94 ($SD = 819.72$) for the trials with threat-related snake distractor;

1810.65 ($SD = 838.57$) for the trials with no information snake distractor; and 1769.55 ($SD = 818.39$) for the trials without any distractor. Skewness of the RT values was 0.85, and log-transformation improved the values' skewness ($skew = -0.12$), therefore log-transformed values were used in the regression. In the regression analyses of this chapter, the RT and eye movement indices means were compared across the three different types of animals and information: threat information snake, no information snake, and (no information) control animal. This predictor variable was coded using two contrasts:

1. Snake (threat information and no information) vs. control animal/no animal: this contrast compared the effect of a snake (regardless of the information given) to a different animal.
2. Threat information snake vs. no information snake: this contrast examined the hypothesis that giving verbal threat information would enhance the attentional bias.

The first contrast examined the hypothesis that there will be a general attentional bias towards snake images. In the case of examining the interference effect of snake images, the control condition is the absence of snake images in the matrix, and therefore, the contrast examines the general distracting effect of snake images on the RTs and on the first fixation times on targets. For the eye movement indices, this contrast compares the means of the indices for the snake images with the means for the amphibian (filler) images. As such, the contrast compares visual attention allocation to snake images relative to amphibian images. The second contrast explores the effect of threat information. In this contrast, the means of the threat information snake will be contrasted with the means of the no information snake for all outcome measures.

In the present analysis, the effect of snake distractors on RTs is examined. Table 4.1 shows the sequential models fitted to the data. The final model was a random intercept model, with fixed slopes for only target presence variable (and no effects of distractor's threat level, and the interaction of distractor threat level and target presence). In this model, heteroscedasticity in the trial type predictor and covariance structure of trials were explicitly modelled. The parameters of this model are summarised in Table 4.2.

Table 4.1. Summary of the model selection process for the RT to decide about the presence of the target.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	-1661.73		
Distractor (FE)	-1661.40	0.67	<i>ns</i>
Target Presence (FE)	-672.64	1977.54	< .0001
Distractor × Target Presence (FE)	-672.11	1.04	<i>ns</i>
Heteroscedasticity (Distractor)	-667.80	9.67	< .01
Covariance structure (Trial)	-604.20	127.21	< .0001
Trial (FE)	-555.87	96.66	< .0001
Trial × Distractor	-554.27	3.19	<i>ns</i>
Trial × Target Presence	-549.78	12.18	< .01
Trial × Distractor × Target Presence	-548.50	2.56	<i>ns</i>
Anxiety	-549.75	0.05	<i>ns</i>
Anxiety × Trial	-547.92	3.72	<i>ns</i>
Anxiety × Distractor	-548.19	3.18	<i>ns</i>
Anxiety × Target Presence	-546.92	5.72	< .05
Anxiety × Target Presence × Distractor	-545.80	2.23	<i>ns</i>
Snake Phobia	-546.34	1.15	<i>ns</i>
Snake Phobia × Trial	-546.54	0.75	<i>ns</i>
Snake Phobia × Distractor	-545.04	3.74	<i>ns</i>
Snake Phobia × Target Presence	-544.64	4.55	< .05
Snake Phobia × Target Presence × Distractor	-544.44	0.39	<i>ns</i>
Distractor (random slopes across participants)	-544.63	1.99	<i>ns</i>

Table 4.2. Summary of the final model predicting RTs to decide about the presence of the target.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	7.6863	0.0360	2741	213.76	< .0001
Distractor Present vs. Distractor Absent	0.0024	0.0037	2741	0.65	<i>ns</i>
Threat Info vs. No Info Distractor	-0.0046	0.0067	2741	-0.69	<i>ns</i>
Target presence	-0.7105	0.0506	2741	-14.03	< .0001
Trial sequence – Linear trend	-2.2507	0.4528	2741	-4.97	< .0001
Trial sequence – Quadratic trend	1.1804	0.4532	2741	2.60	< .01
Target presence × Anxiety	0.0032	0.0013	2741	2.51	< .05
Target presence × Snake phobia score	-0.0053	0.0025	2741	-2.14	< .05

The differences between the trials with snake distractors and trials with no snake distractor, and between the trials with threat information snake and no information snake distractors, were not significant. In other words, displaying a snake as distractor in the stimulus arrays, whether or not threat information had been given about the snake, did not cause a significant delay in the participants' RTs to decide whether a fear-irrelevant target is present or absent in the arrays. The interactions of target presence and anxiety, and target presence and snake phobia scores were significant, indicating that high anxiety was associated with faster responses to the absence of the targets, and higher phobia scores was associated with faster responses to the presence of the targets. These effects, however, were general RT effects and did not depend on the presence and type of distractors in the trials. In other words, anxiety and phobia scores made a difference in specifying the presence of the (fear-irrelevant) targets regardless of the presence of the (threat information and no information) distractors.

In the regression model above, the interaction of the distractor's threat level and target presence did not make any significant improvement in the model. This indicates that target presence did not interact significantly with the distractor's effect, thus, no follow-up analysis was conducted to examine the RTs in each of the target present and target absent conditions.

4.2.2.4. Time of the first fixation on the target

The participants' first fixation times on the targets were slowest when a distractor snake image was displayed in the array. The mean first fixation times on targets were as follows: 771.08 ($SD = 452.41$) for the trials with threat related snake distractor; 787.02 ($SD = 519.79$) for the trials with no information snake distractor; and 740.56 ($SD = 443.74$) for the trials without any distractor. Skewness of the first fixation time values was 1.49, and log-transformation improved the values' skewness ($skew = -0.08$), therefore log-transformed values were used in the regression. Table 4.3 shows the sequential models fitted to the data.

The final model was a random intercept model, in which heteroscedasticity in the distractor's threat level predictor and covariance structure of trials were explicitly modelled. The parameters of this model are summarised in Table 4.4.

Table 4.3. Summary of the model selection process for the first fixation time on targets.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	-1158.97		
Distractor (FE)	-1158.75	0.43	<i>ns</i>
Heteroscedasticity (Distractor)	-1154.86	7.79	< .05
Covariance structure (Trial)	-1151.87	5.98	< .05
Trial (FE)	-1146.66	10.41	< .01
Trial × Distractor	-1141.64	10.04	< .05
Anxiety	-1141.59	0.10	<i>ns</i>
Anxiety × Trial	-1140.18	2.92	<i>ns</i>
Anxiety × Distractor	-1141.46	0.37	<i>ns</i>
Snake Phobia	-1141.51	0.25	<i>ns</i>
Snake Phobia × Trial	-1140.16	2.96	<i>ns</i>
Snake Phobia × Distractor	-1140.27	2.75	<i>ns</i>
Distractor (random slopes across participants)	-1141.64	-	<i>ns</i>

Table 4.4. Summary of the final model predicting the first fixation times on targets.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	6.4438	0.0336	1292	191.61	< .0001
Distractor Present vs. Distractor Absent	0.0156	0.0148	1292	1.05	<i>ns</i>
Threat Info vs. No Info Distractor	0.0094	0.0207	1292	0.46	<i>ns</i>
Trial sequence – Linear trend	-0.7620	1.4162	1292	-0.54	<i>ns</i>
Trial sequence – Quadratic trend	-3.1183	1.2166	1292	-2.56	< .05

There were no significant differences between the trials with snake distractors and the trials with no distractor, and between the trials with threat information snake distractors and the trials with no information snake distractors. These findings indicate that displaying a snake as a distractor in the stimulus arrays, whether or not threat information had been given about the snake, did not cause a significant delay in the participants' first fixation times on the targets.

4.2.2.5. Time of the first fixation on distractors and fillers

The participants' first fixation times were fastest on the threat information snake images. The mean first fixation times on the images were as follows: 914.65 (*SD* = 585.55) for the threat information snake images; 1010.48 (*SD* = 655.67) for the no information snake images; and 996.60 (*SD* = 621.23) for the amphibians (fillers) images. Skewness of the first fixation time values was 0.85, however, log-

transformation did not improve the skewness notably ($\text{skew} = -0.52$), therefore, the non-transformed values were used in the analysis.

As can be seen above, the mean value of the first fixation times on the threat information snake was smaller than this value on the filler images; and on the other hand, the mean value for the filler images was larger than the value for the no information snake. In other words, the value of the mean of the first fixation times on the filler images was between the values of the means of the two types of distractors. Therefore, adding the distractors' means to make the distractors' means category, and contrasting this category with the filler images mean was not reasonable. Thus, unlike the previous analysis, no distractors' means category was made, and the means were compared separately in two regression models.

In the first model, the threat information snake was the baseline category. In this analysis, and the other analyses presented in the following to compare the distractors and filler images, stimulus type includes threat information snake, no information snake, and the fear-irrelevant filler stimuli. Table 4.5 shows the sequential models fitted to the data.

Table 4.5. Summary of the model selection process for the analysis of the first fixation times on distractors and fillers.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	-98351.57		
Stimulus Type (FE)	-98346.13	10.89	< .01
Heteroscedasticity (Stimulus Type)	-98343.38	5.49	<i>ns</i>
Trial (FE)	-98335.73	20.79	< .0001
Trial \times Stimulus Type	-98332.67	6.12	<i>ns</i>
Anxiety	-98335.51	0.44	<i>ns</i>
Anxiety \times Trial	-98333.97	3.53	<i>ns</i>
Anxiety \times Stimulus Type	-98334.64	2.18	<i>ns</i>
Snake Phobia	-98335.52	0.42	<i>ns</i>
Snake Phobia \times Trial	-98334.93	1.60	<i>ns</i>
Snake Phobia \times Stimulus Type	-98334.76	1.94	<i>ns</i>
Stimulus Type (random slopes across participants)	Failed to Converge	-	-

The final model was a random intercept model with fixed effect of the stimulus image type. The parameters of this model are summarised in Table 4.6. In this

regression analysis, the threat information snake was the baseline category of the model's categorical fixed effect (the stimulus image type).

Table 4.6. Summary of the regression model predicting first fixation times on distractor and filler images, with threat information snake image as the baseline category.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	902.08	34.61	12521	26.06	< .0001
No information snake images	100.96	36.72	12521	2.75	< .01
Filler images	87.35	26.46	12521	3.30	< .01
Trial sequence – Linear trend	-2926.80	608.85	12521	-4.81	< .0001
Trial sequence – Quadratic trend	-257	609.09	12521	-0.42	<i>ns</i>

The differences between the means of the threat information snake and both no information snake and filler images were significant, indicating significantly faster first fixations on the threat information snake images than the images of the no information snake and fillers.

In another regression analysis, the means of the filler images with the other two categories were compared. Because the regression model is similar to the model described above, only the relevant regression parameters are reported in the summary table below (Table 4.7). In this regression analysis, the filler image was the baseline category.

Table 4.7. Summary of the regression model predicting first fixation times on distractor and filler images, with filler images as the baseline category.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
No information snake image	13.60	26.71	12521	0.51	<i>ns</i>

There was no significant difference between the first fixation times on the filler images and on the no information snake images. Therefore, the faster first fixation time effect was specific to the threat information snake images.

4.2.2.6. Duration of the first fixation on distractors and fillers

The duration of the first fixation lasted for the longest times on the filler images than the distractor images. The mean first fixation durations were as follows: 174.93 (*SD* = 66.37) for the threat information snake images; 175.17 (*SD* = 65.88) for the no information snake images; and 179.89 (*SD* = 67.65) for the filler images. Skewness of

the first fixation time values was 1.07, however log-transformation did not improve the values' skewness notably (skew = -0.78), therefore, the non-transformed values were used in the analysis. Table 4.8 shows the sequential models fitted to the data.

Table 4.8. summary of the model selection process for the analysis of the first fixation durations on distractors and fillers

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	-70614.68		
Stimulus Type (FE)	-70611.96	5.43	<i>ns</i>
Heteroscedasticity (Stimulus Type)	-70610.74	2.45	<i>ns</i>
Trial (FE)	-70611.05	1.83	<i>ns</i>
Trial \times Stimulus Type	-70611.09	1.74	<i>ns</i>
Anxiety	-70611.19	1.56	<i>ns</i>
Anxiety \times Trial	-70611.86	0.20	<i>ns</i>
Anxiety \times Stimulus Type	-70609.83	4.27	<i>ns</i>
Snake Phobia	-70611.37	1.18	<i>ns</i>
Snake Phobia \times Trial	-70611.79	0.35	<i>ns</i>
Snake Phobia \times Stimulus Type	-70608.21	7.51	<i>ns</i>
Stimulus Type (random slopes across participants)	Failed to Converge	-	-

The final model was a random intercept and fixed slopes model. The parameters of this model are summarised in Table 4.9.

Table 4.9. Summary of the regression model predicting the duration of the first fixation on distractors and filler images.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	176.72	3.46	12578	51.05	< .0001
Distractors vs. Fillers	-1.59	0.69	12578	-2.32	< .05
Threat Info vs. No Info Distractor	-0.47	1.96	12578	-0.24	<i>ns</i>

The difference between the distractor and filler images was significant, but the difference between the threat information snake and the no information snake images was not. These findings indicate that the duration of the first fixation was significantly longer on the filler images than the snake images, but there was no significant difference between the two types of snake images in terms of the first fixation duration.

4.2.2.7. Number of fixations on distractors and fillers

The filler images on average were fixated more frequently than the distractor images. The means of the fixation counts were as follows: 0.70 ($SD = 0.67$) for threat information distractor images; 0.68 ($SD = 0.66$) for the no information snake distractor images; and 0.75 ($SD = 0.75$) for the filler images. Skewness of the fixation count values was 1.19, and log-transformation improved the values' skewness (skew = 0.09), therefore the log-transformed values were used in the analysis. Table 4.10 shows the sequential models fitted to the data.

Table 4.10. Summary of the model selection process for the analysis of the number of fixations on distractors and fillers

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	-10850.35		
Stimulus Type (FE)	-10846.40	7.92	< .05
Heteroscedasticity (Stimulus Type)	-10842.08	8.64	< .05
Trial (FE)	-10785.80	112.54	< .0001
Trial \times Stimulus Type	-10779.05	13.51	< .01
Anxiety	-10778.88	0.33	<i>ns</i>
Anxiety \times Trial	-10775.29	7.51	< .05
Anxiety \times Stimulus Type	-10775.05	0.49	<i>ns</i>
Snake Phobia	-10775.08	0.42	<i>ns</i>
Snake Phobia \times Trial	-10774.03	2.53	<i>ns</i>
Snake Phobia \times Stimulus Type	-10774.69	1.20	<i>ns</i>
Stimulus Type (random slopes across participants)	Failed to Converge	-	-

The final model was a random intercept model with the fixed effect of the stimulus image type in which heteroscedasticity in the fixed effect predictor was explicitly modelled. The parameters of this model are summarised in Table 4.11.

Table 4.11. Summary of the regression model predicting the number of fixations on distractors and filler images.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	0.4575	0.0154	20873	29.65	< .0001
Distractors vs. Fillers	-0.0090	0.0031	20873	-2.88	< .01
Threat Info vs. No Info Distractor	0.0056	0.0089	20873	0.63	<i>ns</i>
Trial sequence – Linear trend	-9.4117	2.0258	20873	-4.65	< .0001
Trial sequence – Quadratic trend	5.9721	2.0244	20873	2.95	< .05

The difference between the distractor and filler images was significant, but the difference between the threat information snake and the no information snake images was not. These findings indicate that the number of fixations on the fear-irrelevant filler images was significantly higher than the snake images, but there was no significant difference between the number of fixations on the two types of snake images.

4.2.2.8. Dwell time on distractors and fillers

The average dwell time was higher on filler images than the distractor images. Dwell time means were as follows: 121.81 ($SD = 125.21$) for threat information distractor images; 118.39 ($SD = 126.84$) for the no information snake distractor images; and 134.21 ($SD = 146.58$) for the filler images. Skewness of the dwell time values was 1.89, and log-transformation improved the values' skewness ($skew = -0.36$), therefore the log-transformed values were used in the analysis. Table 4.12 shows the sequential models fitted to the data.

Table 4.12. Summary of the model selection process for the analysis of dwell times on distractors and fillers.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	-49485.13		
Stimulus Type (FE)	-49483.49	3.27	<i>ns</i>
Heteroscedasticity (Stimulus Type)	-49483.32	0.34	<i>ns</i>
Trial (FE)	-49439.67	87.63	< .0001
Trial \times Stimulus Type	-49432.67	14.02	< .01
Anxiety	-49432.48	0.37	<i>ns</i>
Anxiety \times Trial	-49429.15	7.03	< .05
Anxiety \times Stimulus Type	-49429.01	0.28	<i>ns</i>
Snake Phobia	-49429.02	0.27	<i>ns</i>
Snake Phobia \times Trial	-49428.30	1.71	<i>ns</i>
Snake Phobia \times Stimulus Type	-49428.76	0.78	<i>ns</i>
Stimulus Type (random slopes across participants)	-49429.15	-	-

The final model was a random intercept and fixed slopes model. The parameters of this model are summarised in Table 4.13.

Table 4.13. Summary of the regression model predicting dwell times on distractor and filler images.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	3.1169	0.0900	20873	34.63	< .0001
Distractors vs. Fillers	-0.0365	0.0208	20873	-1.75	<i>ns</i>
Threat Info vs. No Info Distractor	0.0255	0.0595	20873	0.43	<i>ns</i>
Trial sequence – Linear trend	-58.3426	12.9990	20873	-4.49	< .0001
Trial sequence – Quadratic trend	36.9006	12.9911	20873	2.84	< .05

The dwell times on snake images were not significantly different from the dwell times on the filler images; and similarly, there was no significant difference between the dwell times on the threat information and the no information snakes' images.

4.2.2.9. Percentage of dwell time on distractors and fillers

The average percentage of dwell times was higher on the filler images than the distractor images. The means of dwell time percentages were as follows: 0.0699 (*SD* = 0.0713) for the threat information distractor images; 0.0674 (*SD* = 0.0706) for the no information snake distractor images; and 0.0748 (*SD* = 0.0769) for the filler images was. Skewness of the dwell time percentage values was 1.07, and log-transformation improved the values' skewness (skew = 0.82), therefore, the log-transformed values were used in the analysis.

Table 4.14. Summary of the model selection process for the analysis of the percentages of dwell time on distractors and fillers.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	26308.15		
Stimulus Type (FE)	26313.76	11.22	< .01
Heteroscedasticity (Stimulus Type)	26321.84	16.16	< .0001
Trial (FE)	26335.88	28.08	< .0001
Trial × Stimulus Type	26346.04	20.32	< .0001
Anxiety	26346.59	1.10	<i>ns</i>
Anxiety × Trial	26347.72	3.37	<i>ns</i>
Anxiety × Stimulus Type	26346.70	1.32	<i>ns</i>
Snake Phobia	26346.51	0.95	<i>ns</i>
Snake Phobia × Trial	26346.47	0.86	<i>ns</i>
Snake Phobia × Stimulus Type	26347.38	2.69	<i>ns</i>
Stimulus Type (random slopes across participants)	Failed to Converge	-	-

Table 4.14 shows the sequential models fitted to the data. The final model was a random intercept model, with fixed effect of the stimulus image type, in which heteroscedasticity in the stimulus image type predictor was explicitly modelled. The parameters of the final model are summarised in Table 4.15.

Table 4.15. Summary of the regression model predicting the percentages of dwell time on distractor and filler images.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	0.0661	0.0016	20875	40.89	< .0001
Distractors vs. Fillers	-0.0018	0.0005	20875	-3.53	< .001
Threat Info vs. No Info Distractor	0.0010	0.0015	20875	0.65	<i>ns</i>
Trial sequence – Linear trend	-0.8908	0.1438	20875	-6.19	< .0001
Trial sequence – Quadratic trend	0.2573	0.1448	20875	1.78	< .05

The percentage of dwell time was significantly lower on the snake images than the fear-irrelevant filler images. However, the difference between the means of the percentages of dwell times on threat information snake images and no information snake images was not significant.

4.2.2.10. The first fixated image

In one third of the experiment trials, target and distractor images were displayed in the same stimulus array. To examine whether the snake images distracted participants from the instructed task, that is finding the target, and attracted involuntary saccades, we analyse on which one of these two images in the arrays participants fixated first, and whether the threat information snake images were fixated before the target more often than no information snake images were fixated before their relevant targets.

In the trials with the threat information snake distractor, the target was fixated before the distractor 314 times, and the distractor was fixated before the target 136 times. In the trials with the no information snake as distractor, the target was fixated before the distractor 323 times, and the distractor was fixated before the target 130 times. In 8 trials of the threat information distractor condition and 4 trials of the no information distractor condition, none of the target or distractor images were fixated. These trials were excluded from the analysis.

The counts of the first fixated image were compared in a multilevel regression analysis. Table 4.16 shows the sequential models fitted to the data.

Table 4.16. Summary of the model selection process for the analysis of the first fixated image (whether the target image or the distractor image is fixated first in the stimulus arrays).

Model	Log-Likelihood	χ^2	<i>p</i>
Baseline	-546.20		
Distractor (FE)	-546.07	0.26	<i>ns</i>
Trial (FE)	-541.07	10.01	< .01
Trial \times Distractor	-540.09	1.95	<i>ns</i>
Anxiety	-539.66	2.81	<i>ns</i>
Anxiety \times Trial	-538.92	4.29	<i>ns</i>
Anxiety \times Distractor	-540.42	1.30	<i>ns</i>
Snake Phobia	-540.38	1.37	<i>ns</i>
Snake Phobia \times Trial	-540.91	0.32	<i>ns</i>
Snake Phobia \times Distractor	-540.43	1.29	<i>ns</i>
Distractor (random slopes across participants)	-541.04	0.05	<i>ns</i>

The final model was a random intercept and fixed slopes model. Table 4.17 shows the parameters for this final model.

Table 4.17. Summary of the regression model predicting the frequency of the first fixated image.

	<i>b</i>	<i>SE b</i>	<i>z</i>	<i>p</i>
Intercept	0.9377	0.1163	8.06	< .0001
Distractor's threat level	-0.0709	0.1475	-0.48	<i>ns</i>
Trial sequence— Linear trend	7.0729	2.2505	3.14	< .01
Trial sequence— Quadratic trend	0.7747	2.2402	0.35	<i>ns</i>

The distractor's threat level did not significantly predict the frequency of the first fixated image. This finding indicates that the differences in the frequency of the first fixated images in the two distractors' conditions did not depend on the distractors. In other words, whether the target image or the distractor image was fixated first was not significantly different in the trials with the threat information distractor, as compared to the trials with the no information distractor.

4.2.3. Discussion

The presence of snake images in the stimulus arrays did not cause any significant delay in the participants' manual RTs when deciding about the presence of the targets in the array, and in the participants' first fixation time on the targets. Moreover, distractor images were not fixated before the target images more frequently, therefore, uninstructed fixations on the distractor images were not found. This was the case for both types of snake stimuli, that is, the snake about which threat information was given, and the snake about which the participants were not given any information. Therefore, neither a general attentional bias effect towards snake stimuli as fear-relevant stimuli, nor an additional attentional bias effect caused by threat information, was found. Thus, the main hypotheses of this experiment, that is, the first and second hypotheses, are rejected. These findings are inconsistent with several studies that have shown attentional bias to fear-relevant animals, and in particular, snakes stimuli (Öhman, Flykt, et al., 2001; Soares, Esteves, Lundqvist, et al., 2009). More specifically, the results are inconsistent with the studies in which interference effect of fear-relevant stimuli, mainly spiders, has been found (e.g., Miltner, et al., 2004; Rinck, et al., 2005; Lipp & Waters, 2007). The specific effect of uninstructed fixations on the spider distractor images before the target, found in spider phobic participants of Miltner et al.'s (2004) study, was not found in the current experiment. Moreover, contrary to the predictions, an assumed fear induction through an indirect fear pathway (information) did not result in an additional attentional bias towards the fear-relevant animal about which threat information was given. This conclusion is inconsistent with previous studies which showed that acquiring fear of a fear-irrelevant animal (Australian marsupials) after receiving threat information is associated with the acquisition of attentional bias towards the newly feared animal (Field, 2006c, 2006a). The results are also inconsistent with the studies (e.g., Gerull & Rapee, 2002) which showed that induction of additional fear of fear-relevant animals (spiders) through indirect fear pathways, namely vicarious learning, resulted in increased fear responses to the fear-relevant animal stimuli.

In addition to the main hypotheses of this experiment which pertain to the distraction effect of threat stimuli, and were tested indirectly (by measuring the potential delay caused by the threat stimuli in detecting the target), the extra hypothesis pertaining to the direct allocation of visual attention to the threat stimuli was also tested.

This was done by comparing the fear-relevant (distractors) and fear-irrelevant (fillers) stimuli in terms of the eye movement indices data. The results showed significant faster first fixations on threat information snake images comparing with the no information snake and fear-irrelevant amphibian images. This is the only effect of threat information found in this experiment. In addition to this fast gaze direction to the high threat stimulus images, the results imply on a general pattern of avoidance of the fear-relevant images. Such avoidance can be inferred from shorter durations of the first fixations, fewer number of fixations, and lower percentages of dwell time on the snake images as compared to fear-irrelevant amphibian images. Thus, there might be some indications of a vigilant-avoidant pattern of attention towards the images of the snake about which threat information was given, and some signs of avoidance of the snake stimuli in general.

It should, however, be noted that this experiment was designed to examine the distraction effect of snake images in detecting fear-irrelevant targets, and comparing the visual attention allocation responses to the snake and filler images was not the primary purpose of the study. For this part of the analysis, the comparison bases were not equal, because in the relevant trials, a single image of snake were compared with 6 or 7 amphibian images presented in the trial's stimulus array. Thus, the results should be interpreted with caution.

Nonetheless, the only notable findings of the study were obtained by direct comparison of snake and filler stimuli in terms of eye movement data; whereas testing the main hypotheses of this study resulted neither in finding the basic distraction effect of snake images, nor finding the additional distraction effect caused by fear induction. This implies that in examining threat-relevant attentional biases for the current study's purposes, measuring indices of direct visual attention allocation to the stimuli might be more effective than measuring the stimuli's distraction effect. This was pursued in the next experiment of this chapter. In the next experiment, the study's stimuli (i.e., the threat information snake, the no information snake, and the fear-irrelevant animal) were compared in terms of overt attention deployment indices. In the next experiment, the bias effects were measured using two variants of the visual search task, that is, the target search and the odd-one-out search tasks.

In the current experiment, in over forty percent of the trials in which a snake distractor was displayed, the distractor's image was not fixated. It seems that the single snake image displayed in the stimulus arrays of the current experiment to the people

with low snake phobia scores lacked the strong distracting effect that the single image of the fear-relevant animals (spider and snake) have shown to have for the phobic and non-phobic participants in the previous studies (e.g., Miltner, et al., 2004; Lipp & Waters, 2007). For instance, Miltner et al.'s (2004) argued against the mass presentation of fear-relevant distractors in stimulus arrays and showed that even a single fear-relevant distractor can cause attentional bias. In Miltner et al.'s study, spider phobic participants fixated the spider images before fixating the target stimulus arrays more often than did the non-phobic participants. This was not the case for the present experiment, and it is possible that the mass presentation of the distractor images can have the distracting effect similar to the effect shown in other attentional bias studies (e.g., Rinck, et al., 2005). Thus, in one of the search tasks of the next experiment, the fear-relevant distractor images were presented in high numbers in stimulus arrays. This ensured us that the fear-relevant distractors were seen in the matrix before the trial was terminated.

Another potential issue with the present experiment can be the animal images used as stimuli. Some of the salamander images used as filler images might have been similar to the snake images. As expected and discussed by Lipp (2006), similarity between the background images and the deviant image can attenuate the attentional bias effect. In the next experiment, therefore, salamander images were excluded from the search tasks matrices.

In the current experiment, a cautious approach was taken towards time constraints which might have been unnecessary. Testing time of the next experiment was extended to allow us to include in the experiments some other parts which were considered useful. A fear belief questionnaire was administered to measure directly the effect of threat information on the participants' fear responses to the snake about which the information was given. Moreover, a short, multiple choice, test about the threat information was also included in the experiment to ensure that the participants would attempt to concentrate on the information that they were given. Finally, two search tasks were administered to measure both direct attention allocation to fear-relevant targets and the distracting effect of the stimuli.

4.3. Experiment 2

In the previous experiment no interference effect of snake images, in general, and no added interference effect of the threat information snake images, in particular, was found. Evidence, however, was found for differential attention allocation to fear-relevant and fear-irrelevant stimuli images, and in one case to the threat information snake images relative to the no information snake. Therefore, for the purpose of the current study, it was predicted that using the search tasks that particularly aim to tap the pattern of visual attention allocation to different stimuli, rather than tapping their mere interference effect would be more effective. In this experiment, two other variants of the visual search task, that is, the target search, and the odd-one-out (or deviant) search tasks, were used. In the target search task, the participants are instructed to find a pre-defined target in the stimulus arrays. In the target search task used in this experiment, the RTs to detect threat information fear-relevant, no information fear-relevant, and fear-irrelevant targets, and overt attention deployment to the targets, were compared to examine the attentional bias towards the targets. The instruction of the odd-one-out search task is to search for a deviant image in the stimulus arrays, and there is no predefined target in the arrays. In the odd-one-out search task employed in this experiment, the threat information, no information, and non-threat stimuli were used as both target and distractors in the arrays (see the task description below), therefore, both target detection and interference effects were examined in this task.

In the current experiment, in addition to the anxiety, snake phobia, and stimuli attitude scales used in the previous experiment, two other scales were administered: the information recall scale was added to encourage the participants to concentrate on the threat information given, and the snake fear belief scale was added to measure the potential changes in fear beliefs caused by the threat information. An increase in fear beliefs of the snake about which threat information was given was considered as a sign of the acquisition of fear of the snake. The first hypothesis of this experiment was that receiving the threat information about a snake would significantly increase the participants' fear beliefs about it.

The second and third hypotheses were about detection and interference effects of threat stimuli on RTs. As the second hypothesis it was predicted that RTs would be significantly faster when detecting the snake images amongst the filler images than

detecting the control target images amongst the filler images, and that the RTs to detect the threat information snake stimuli would even be faster than the RTs to detect the no information snake stimuli. As the third hypothesis it was predicted that the RTs to detect fear-irrelevant animal targets amongst snake images would be significantly slower than the RTs to detect fear-irrelevant animal targets when displayed amongst fear-irrelevant animal images.

The fourth and fifth hypotheses were about the effect of threat stimuli on eye movement responses. As the fourth hypothesis it was predicted that the eye movement indices would display an attention prioritisation of snake targets over control targets, and the threat information snakes over the no information snakes. As the fifth hypothesis it was predicted that when detecting fear-irrelevant target images amongst snake images and amongst fear-irrelevant animal images, the eye movement indices would display higher interference effect of snake images as compared to fear-irrelevant animal images, and higher interference effect of threat information snake images as compared to the no information snake images.

4.3.1. Method

4.3.1.1. Participants

Thirty-six adults aged between 18 and 36 ($M = 21.89$, $SD = 4.23$) participated in the study, of which 22 were female and 14 were male. They were randomly assigned to two groups. One of the groups were given threat information about one of the snakes (the beige snake) and no information about the other snake (the brown snake), and the other half of the sample received information in the opposite order. The groups were matched in terms of gender. One of the participants who had a high snake phobia score was excluded from the analysis. As mentioned before, this exclusion criterion was set to avoid recruiting participants with ceiling levels of attentional bias to snake images. The eye movement data of another participant were lost due to a failure in the transfer of data file from the eye tracker to the host computer. The final sample, therefore, consisted of 34 participants.

4.3.1.2. Materials

The same measures of anxiety, snake phobia, and Stimuli Attitude Scales used in the previous experiment were employed in the current experiment. In the current

experiment's sample, Cronbach's α for the anxiety test was .90, and for the snake phobia test was .81, both indicating the tests' good reliability. The same threat information was also given about the snake stimuli in the current experiment, with the exception that the physical descriptions of one of the snakes in the information was adapted to describe the new snake species whose images were used in this experiment stimulus arrays. As mentioned before, the Snake Fear Beliefs Questionnaire, and the information recall scale were the two new scales employed in this experiment and are described in the following:

The Snake Fear Beliefs Questionnaire was designed to measure the changes in the participants' fear beliefs about the snakes after receiving the threat information. The scale consists of 9 items with the score range of 0-36 (Appendix H). The questions aim to measure fear signs based on the Lang's model of fear response systems (e.g., Lang, et al., 1983). Thus, each question corresponds to one of the fear signs in the model, that is, somatic (e.g., would you feel sick if you saw this snake?), behavioural avoidance (if you saw this snake, would you approach it to take a closer look?), and cognitive (do you think this type of snake is not dangerous and does not cause any harm to humans?). Similar to the FBQ scale (Field & Lawson, 2003) used in the experiments of Chapter 3, the participants were asked to endorse each statement on a 5-point Likert response scale including 0 = No, not at all; 1 = No, not really; 2 = Don't know/neither; 3 = Yes, probably; 4 = Yes, definitely. Three questions of the scale are positive and need to be reversed-scored.

The Information Recall Scale was designed to measure the participants' accuracy in remembering the threat information. The aim of administering this questionnaire was only to encourage focusing on the details of the information, and the recall scores were not analysed. The scale consists of 10 multiple choice questions about the threat information content, with four answer options for each question (Appendix H).

The visual search tasks: two variants of visual search task were administered in the current experiment.

In the target search task, the participants searched for a target image amongst filler images. The specifications of the stimulus arrays were similar to the previous experiment, except for some changes in the images used. In this task, three animals' images, including one type of fish and two types of snakes, served as targets, and different frogs' images served as fillers. Eight exemplar images of each of the target images, that is, the Dwarf Gourami fish, the California King Snake (the brown snake),

and the Pacific Gopher (the beige snake), and 128 exemplar images of frogs and toads were used in the matrices (see Appendix I for some examples). The matrices of the target search task were composed of different images in different locations, and it was ensured that each matrix was a unique combination of filler and target images. This task consisted of 72 trials, of which 48 trials were target present and 24 trials target absent. The stimulus arrays in the target present trials consisted of one target image and 8 filler images; and in the target absent trials all the grid locations of the stimulus arrays were allocated to the filler images. In 16 trials of the target present condition the target was fish, in 16 trials it was the brown snake, and in the other 16 trials it was the beige snake. There were 6 practice trials, 3 of which were target absent and the other 3 trials were target present.

In the first experiment of this chapter, the images of the Black Racer snake were used as one of the snake stimuli. This snake's images were not used in the current experiment because they did not look similar enough for the use in the odd-one-out search task. As described below, in most of the trials of the odd-one-out search task, the stimulus arrays consisted of 8 distractor images of one type of animal and 1 target image of another type. In these trials, all the distractor images are used in the same stimulus arrays, therefore they needed to be similar enough to ensure of the stimuli homogeneity which is necessary due to the task instruction (i.e., specifying whether there is a different image among the similar images of the stimulus array). For this reason, similar images of the Pacific Gopher snake were selected to be used in the matrices instead of the Black Racer snake images. The brown snake images were similar enough to be used in these stimulus arrays, and similar images of the same fish and frog species were also selected to fulfil this condition. Nine exemplar images of each of the animal images were used in the of the odd-one-out task matrices.

A thorough search was carried out to find the suitable images for the odd-one-out search task matrices. The process of selecting the images started from searching on the internet for at least 9 similar images for each of the animals whose images were intended to be used in the matrices (i.e., snake, frog, and fish). Through this search, several similar images of different species of snakes, frogs, and fish were found. Then 9 images of each species were selected, which were then adjusted and put together in a matrix. This process yielded several 9-image-matrices for each one of the animals, that is, several matrices of fish images, several matrices of frog images, and several matrices of snake images. Out of these matrices, one matrix for each animal was selected, which

served as the 9 exemplar images used in the final matrices of the visual search task. This final selection was based on the judgement of the experimenter, and several researchers and doctoral students in the School of Psychology who assisted the experimenter in choosing the stimuli. These researchers viewed different combinations of the stimuli in the task matrices (e.g., fish target in frog distractors, fish targets in snake distractors, and so on) and helped the experimenter to choose the best possible exemplars. In this selection, the aim was that the 9 exemplar images of each species look most similar, and at the same time, the distinction between the target (fish images) and fear-relevant distractors (snake images) was at a similar level as the distinction between the target and control distractors (frog images).

The task matrices consisted of 8 similar images of one species (distractors) and 1 image of another species (the deviant) in the target present trials, or of 9 similar images of one species in the target absent trials. The task consisted of 72 trials, of which 48 trials were target present, and the remaining trials were target absent. Similar to the previous experiment, the target (the deviant image) was not displayed in the central grid location, and was displayed equally in the remaining grid locations. There were two conditions in this task: target detection condition, and the distraction by threat condition. In the first condition, the target present trials consisted of a deviant image (the target), which was an image of the threat information snake, of the no information snake, or of the control fear-irrelevant animal (fish), and the distractors were 8 similar frog images. There were 8 trials for each of the three target species, and each target species was displayed in each grid locations once, therefore, 24 target present trials in the target detection condition. In the distraction condition, each target present trial consisted of a deviant image of a frog and 8 distractor images of one of the types of the above mentioned stimuli (i.e., the threat information snake, the no information snake, or the fear-irrelevant control animal). There were 8 trials for each distractor species, thus, 24 target present trials in the distractor condition. In sum, the target present trials of the task consisted of 8 trials with fish as the target and frogs as distractors, 8 trials with the no information snake as the target and frogs as distractors, 8 trials with the threat information snake as the target and frogs as distractors, 8 trials with frog as the target and fish as distractors, 8 trials with frog as the target and the no information snake as distractors, 8 trials with frog as the target and the threat information snake as distractors. Similar to the previous task, the target absent trials were half the number of the matrices of the target present trials. Therefore, the 24 target absent trials included 12 trials with

matrices consisted of 9 frog images, 4 trials with matrices consisted of 9 fish images, 4 trials with matrices consisted of 9 no information snake images, and 4 trials with matrices consisted of 9 threat information snake images. In both target and odd-one-out search tasks, the target absent trials were included to encourage the participants to concentrate on the task, therefore, these trials were excluded from the tasks' data analyses.

4.3.1.3. Procedure

Participant's recruitment was similar to the pervious experiment. The participants completed the experiment individually. They were asked to read the information sheet, and sign the consent form upon arrival at the laboratory (Appendix D). They then answered the stimuli attitude scale, and the experimenter reviewed their answers to examine their eligibility for taking part in the experiment. None of the participants was excluded based on their answer to this scale. They then answered the Snake Fear Beliefs Questionnaire, as the fear beliefs baseline measure, for each of the two snakes whose images were used in the visual search tasks. The participants continued by listening through earphones the threat information sound file which was read by a female in her late 20s. The Snake Fear Beliefs Questionnaire was administered again as a post-test after the participants listened to the sound file. Four images of the snakes were also shown to the participants on the screen while they answered the baseline and post-test questionnaires, and listened to the sound file. After the post-test questionnaire, they answered the Information Recall Scale. The participants were then sat at the desk on which the eye tracking devices were placed, and were asked to put their chin on the headrest of the camera tower. The chair and headrest were adjusted, and the eye tracker was calibrated, and after the calibration, the visual search tasks started by reading the instructions page of the task. For the target search task, the participants were asked to press the right button if they saw a fish or a snake image amongst the frog images, and the left button if there was not any fish or snake in the image matrix. For the odd-one-out search task, they were asked to press the right button if there was an animal of a different type among other animal images in the image matrix, and the left button if all the animals in the matrix were from the same type of animal. The instructions were also explained verbally, and both speed and accuracy was emphasised, with a special emphasis on accuracy. Participants began with 8 practice trials, and were asked whether

the practice trials were enough and they could start the experiment, or whether they needed more practice. None of the participants needed more practice. After the practice trials, they completed the two search tasks, and between the two tasks, and also after 36 trials of each task, they were asked to have a break. The order of the visual search tasks was counter-balanced so that half the participants received the target search first, and the other half the odd-one-out search first. After the visual search task, the participants were asked to answer the anxiety and snake phobia scales, were paid for their time, debriefed, and dismissed.

4.3.2. Results

4.3.2.1. Trait anxiety

The participants' trait anxiety scores were between 24 and 60 ($M = 39.28$, $SD = 8.16$).

4.3.2.2. Snake phobia

The participants' snake phobia scores were between 1 and 18 ($M = 5.08$, $SD = 3.91$).

4.3.2.3. Snake Fear Beliefs

Figure 4.1 shows the mean fear beliefs of the two snakes before and after listening to the threat information about one of the snakes. These were as follows: the mean fear beliefs for no information snake in baseline measurement was 1.89 ($SD = 0.73$), the mean fear beliefs for threat information snake in baseline measurement was 1.66 ($SD = 0.59$), the mean fear beliefs for the no information snake in post-test measurement was 2.13 ($SD = 0.70$), and the mean fear beliefs for the threat information snake in post-test measurement was 2.95 ($SD = 0.57$). A 2 (type of information: threat vs. none) \times 2 (time: before vs. after information) repeated measure analysis of variance revealed significant effects of time, $F(1, 35) = 144.94$, $p < .0001$; information, $F(1, 35) = 12.49$, $p < .001$; and most importantly, information \times time interaction, $F(1, 35) = 74.78$, $p < .0001$, which indicates that the change in fear beliefs in the post-test depended on the type of information given. The pre- and post-test FBQ means were compared using four t -tests. It was found that the mean fear beliefs of the no information snake in the pre-test was significantly higher than the threat information snake FBQ mean, $t(35) = 2.48$, $p < .05$.

Moreover, in the post-test measurement, the mean fear beliefs of the no information snake significantly increased comparing the scores mean in the pre-test, $t(35) = -2.88$, $p < .01$. Similarly, the mean fear beliefs of the threat information snake in the post-test was significantly higher than the scores mean in the pre-test, $t(35) = -13.74$, $p < .0001$. However, the increase in the mean fear beliefs of the threat information snake was remarkably more than the increase in the mean for the no information snake. This resulted in a significantly higher FBQ mean for the threat information as compared to the no information snake in the post-test measurement, $t(35) = 7.19$, $p < .0001$.

It should be noted that in the pre-test, the FBQ means of the no information snake was significantly higher than the threat information snake. However, as seen above, receiving the threat information changed this direction, and in the post-test, as predicted, fear beliefs of the threat information snake was significantly higher than the no information snake. It was predicted that the significant difference in the fear beliefs about the two snakes would be reflected in the patterns of attention to the snake images.

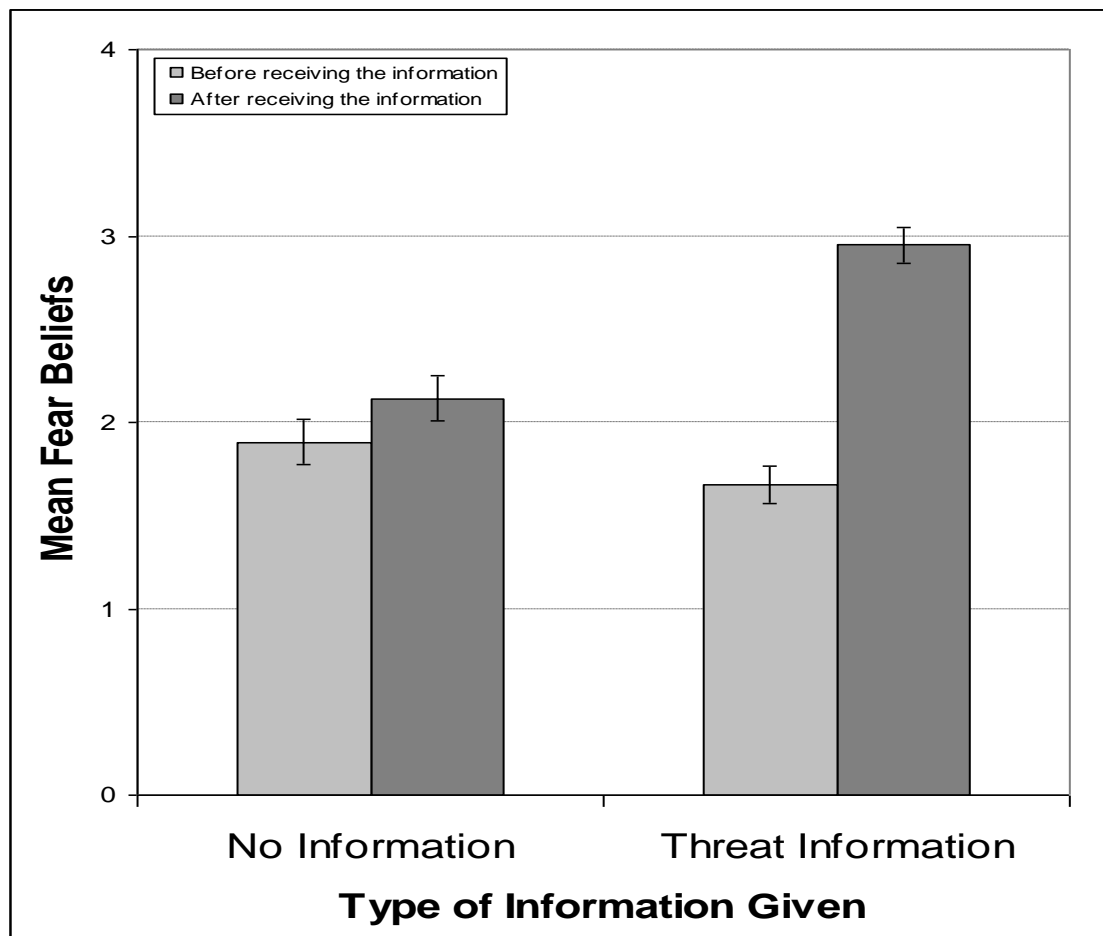


Figure 4. 3. Graph showing mean fear beliefs (and their standard errors) in the baseline and post-test measurements for no information and threat information groups.

4.3.2.4. The target search task: RT data

The participants' reaction times were fastest when detecting the snake images. The mean RTs were as follows: the mean RTs to detect the threat information snake was 1156.01 ($SD = 517.80$); the mean RTs to detect the no information snake was 1136.48 ($SD = 475.39$); and the mean RTs to detect fish targets was 1324.22 ($SD = 544.86$). Skewness of RT values was 1.49, and log-transformation improved the values' skewness (skew = 0.52), therefore log-transformed values were used in the regression. Table 4.18 shows the sequential models fitted to the data. The final model was a random intercept model, with fixed and random effects of the target threat level and fixed effect of trial sequence, in which covariance structure of trials were explicitly modelled. The parameters of this model are summarized in Table 4.19.

Table 4.18. Summary of the model selection process for the RTs to detect the targets.

Model	Log-Likelihood	LR	<i>p</i>
Baseline	-495.75		
Target (FE)	-455.67	80.17	< .0001
Heteroscedasticity (Target)	-454.84	1.66	<i>ns</i>
Covariance structure (Trial)	-446.41	18.51	< .0001
Trial (FE)	-434.52	10.41	< .01
Trial \times Target	-417.43	34.18	< .0001
Anxiety	-417.36	0.14	<i>ns</i>
Anxiety \times Trial	-415.85	3.15	<i>ns</i>
Anxiety \times Target	-415.50	3.85	<i>ns</i>
Snake Phobia	-417.18	0.49	<i>ns</i>
Snake Phobia \times Trial	-416.88	1.08	<i>ns</i>
Snake Phobia \times Target	-417.09	0.67	<i>ns</i>
Target (random slopes across participants)	-411.68	11.48	< .05

Table 4.19. Summary of the regression model predicting RTs to detect the targets.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	6.4045	0.1136	1545	56.38	< .0001
Snake vs. Fish Targets	0.5130	0.1064	1545	4.82	< .0001
Threat Info vs. No Info Targets	0.0040	0.0268	1545	0.1494	<i>ns</i>
Trial sequence – Linear trend	22.0720	4.3786	1545	5.04	< .0001
Trial sequence – Quadratic trend	-10.9395	1.7473	1545	-6.26	< .0001

There was a significant difference between the means of the trials with snake and fish targets, indicating that the RTs were significantly faster to detect the snake targets than the fish targets. The mean RTs to detect threat information and no information snakes were, however, not significantly different.

4.3.2.5. The target search task: Time of the first fixation on the target

The participants' first fixations were faster on the snake images comparing with fish images. The mean first fixation times were as follows: 705.55 ($SD = 429.28$) for the threat information snake; 669.94 ($SD = 388.32$) for the no information snake; and 780.50 ($SD = 501.08$) for the fish targets. Skewness of the first fixation time values was 1.85, and log-transformation improved the values' skewness ($skew = 0.43$), therefore log-transformed values were used in the regression. Table 4.20 shows the sequential models fitted to the data.

Table 4.20. Summary of the model selection process for the first fixation times on targets.

Model	Log-Likelihood	LR	<i>p</i>
Baseline	-1138.99		
Target (FE)	-1132.29	13.40	< .01
Heteroscedasticity (Target)	-1118.28	28	< .0001
Covariance structure (Trial)	-1095.79	44.99	< .0001
Trial (FE)	-1087.63	16.33	< .01
Trial \times Target	-1076.26	22.75	< .0001
Anxiety	-1076.25	0.01	<i>ns</i>
Anxiety \times Trial	-1074.56	3.38	<i>ns</i>
Anxiety \times Target	-1073.09	6.33	<i>ns</i>
Snake Phobia	-1075.74	1.03	<i>ns</i>
Snake Phobia \times Trial	-1075.60	1.32	<i>ns</i>
Snake Phobia \times Target	-1075.72	1.07	<i>ns</i>
Target (random slopes across participants)	Failed to Converge	-	-

The final model was a random intercept model, with the fixed effects of target's threat level and trial sequence, in which both heteroscedasticity in the target threat level predictor, and covariance structure of trials were explicitly modelled. The parameters of this model are summarized in Table 4.21.

Table 4.21. Summary of the regression model predicting first fixation times on targets.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	5.7038	0.1983	1530	28.76	< .0001
Snake vs. Fish Targets	0.6501	0.1926	1530	3.38	< .001
Threat Info vs. No Info Targets	0.0530	0.0415	1530	1.28	<i>ns</i>
Trial sequence – Linear trend	26.9181	7.9801	1530	-3.67	< .001
Trial sequence – Quadratic trend	-11.7881	3.2111	1530	-3.58	< .001

There was a significant difference between the trials with snake and fish targets, indicating that the participants fixated the snake targets significantly faster than the fish targets. The first fixation times on the threat information snake and on the no information snake were, however, not significantly different.

4.3.2.6. The target search task: Duration of the first fixation on the target

Durations of the first fixations were longer on the snake target images than the fish target images. The mean first fixation durations were as follows: 244.74 (*SD* = 98.89) for the threat information snake; 252.87 (*SD* = 100.78) for the no information snake; and 215.20 (*SD* = 105.67) for the fish targets. Skewness of the first fixation duration values was 1.08, however, the log transformation did not improve the values' skewness notably (*skew* = -0.54), therefore the non-transformed values were used in the model. Table 4.22 shows the sequential models fitted to the data.

The final model was a random intercept model, with the fixed effect of the target threat level, in which neither heteroscedasticity in the target threat level predictor, nor covariance structure of trials, were modelled. The parameters of this model are summarised in Table 4.23.

There was a significant difference between the trials with snake and fish targets, indicating that the participants' first fixations lasted significantly longer on the snake targets than the fish targets. The durations of the first fixation on the threat information snake was, however, not significantly different from the durations on the no information snake.

Table 4.22. Summary of the model selection process for the duration of the first fixations on targets.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	−9465.79		
Target (FE)	−9445.16	41.27	< .0001
Heteroscedasticity (Target)	−9443.34	3.63	<i>ns</i>
Covariance structure (Trial)	−9445.14	0.04	<i>ns</i>
Trial (FE)	−9443.55	3.22	<i>ns</i>
Anxiety	−9444.89	0.54	<i>ns</i>
Anxiety × Trial	−9444.58	1.16	<i>ns</i>
Anxiety × Target	−9443.80	2.71	<i>ns</i>
Snake Phobia	−9444.64	1.03	<i>ns</i>
Snake Phobia × Trial	−9444.62	1.07	<i>ns</i>
Snake Phobia × Target	−9444.10	2.13	<i>ns</i>
Target (random slopes across participants)	Failed to Converge	-	-

Table 4.23. Summary of the regression model predicting the duration of the first fixations on targets.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	238	6.06	1536	39.29	< .0001
Snake vs. Fish Targets	10.93	1.73	1536	6.33	< .0001
Threat Info vs. No Info Targets	-3.86	2.98	1536	-1.30	<i>ns</i>

4.3.2.7. The target search task: Dwell time on the target

The participants dwelled for longer times on the fish target images comparing with the snake target images. The mean target dwell times were as follows: 347.75 (*SD* = 173.36) for the threat information snake; 350.35 (*SD* = 173.77) for the no information snake; and 366.95 (*SD* = 176.54) for the fish targets. Skewness of the dwell time values was 1.46, and log-transformation improved the values' skewness (skew = −0.46), therefore the log transformed values were used in the regression model. Table 4.24 shows the sequential models fitted to the data.

The final model was a random intercept model with trial sequence as the fixed effect, in which both heteroscedasticity in the target threat level predictor, and covariance structure of trials were modelled. The parameters of this model are summarized in Table 4.25.

Table 4.24. Summary of the model selection process for dwell times on targets.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	-997.31		
Target (FE)	-995.68	3.26	<i>ns</i>
Heteroscedasticity (Target)	-987.17	17.04	< .0001
Covariance structure (Trial)	-984.26	5.82	< .05
Trial (FE)	-977.57	13.38	< .01
Trial × Target	-975.84	3.46	<i>ns</i>
Anxiety	-977.55	0.04	<i>ns</i>
Anxiety × Trial	-977.13	0.87	<i>ns</i>
Anxiety × Target	-977.35	0.43	<i>ns</i>
Snake Phobia	-977.49	0.15	<i>ns</i>
Snake Phobia × Trial	-976.93	1.28	<i>ns</i>
Snake Phobia × Target	-977.19	0.76	<i>ns</i>
Target (random slopes across participants)	-974.75	5.65	<i>ns</i>

Table 4.25. Summary of the regression model predicting dwell times on targets.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	5.7553	0.0391	1534	147.04	< .0001
Snake vs. Fish Targets	-0.0665	0.0187	1534	-3.56	< .001
Threat Info vs. No Info Targets	-0.0066	0.0137	1534	-0.48	<i>ns</i>
Trial sequence – Linear trend	-2.6722	0.9602	1534	-2.78	< .001
Trial sequence – Quadratic trend	-2.1933	0.6103	1534	-3.59	< .001

There was a significant difference between the trials with snake and fish targets, indicating that the participants dwelled for significantly longer times on the fish images than on the snakes' images. There was no significant difference between the dwell times on the threat information snake and the no information snake.

4.3.2.8. The target search task: Percentage of dwell time on the target

Unlike the dwell times, the percentages of the dwell times were higher on the snake than the fish targets. The mean dwell time percentages were as follows: 0.3790 (*SD* = 0.1522) for the threat information snake; 0.3850 (*SD* = 0.1486) for the no information snake; and 0.3592 (*SD* = 0.1641) for the fish targets. Skewness of the dwell time percentage values was negligible (*skew* = 0.15), therefore, the non-transformed values were used in the regression model. Table 4.26 shows the sequential models fitted to the data. The final model was a random intercept model with the fixed effects of target's

threat level and trial sequence, in which both heteroscedasticity in the target threat level predictor, and covariance structure of trials were modelled. The parameters of this model are summarised in Table 4.27.

Table 4.26. Summary of the model selection process for percentages of dwell times on targets.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	783.54		
Target (FE)	787.95	8.82	< .05
Heteroscedasticity (Target)	794.01	12.12	< .01
Covariance structure (Trial)	803.49	18.97	< .0001
Trial (FE)	811.62	16.24	< .01
Trial \times Target	822.75	22.26	< .0001
Anxiety	822.75	0.01	<i>ns</i>
Anxiety \times Trial	823.78	2.07	<i>ns</i>
Anxiety \times Target	824.67	3.83	<i>ns</i>
Snake Phobia	822.77	0.04	<i>ns</i>
Snake Phobia \times Trial	823.11	0.73	<i>ns</i>
Snake Phobia \times Target	822.79	0.08	<i>ns</i>
Target (random slopes across participants)	Failed to Converge	-	-

Table 4.27. Summary of the regression model predicting the targets dwell time percentages.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	0.5850	0.0548	1530	10.67	< .0001
Snake vs. Fish Targets	-0.2037	0.0532	1530	-3.82	< .001
Threat Info vs. No Info Targets	-0.0038	0.0121	1530	-0.31	<i>ns</i>
Trial sequence – Linear trend	-8.5973	2.2095	1530	-3.89	< .001
Trial sequence – Quadratic trend	3.1614	0.8868	1530	3.56	< .001

There was a significant difference between the percentages of the dwell time on the trials with snake targets and the trials with fish targets, indicating that the dwell time percentages were higher on the snake targets relative to the fish targets. There was, however, no significant difference between the percentages of dwell time on the threat information and no information snake images.

4.3.2.9. The target search task: Number of fixations on the target

The participants fixated more often on the fish target images comparing with the snakes target images. The mean fixation counts on the targets were as follows: 1.52 ($SD = 0.73$) on the threat information snake; 1.49 ($SD = 0.72$) on the no information snake; and 1.77 ($SD = 0.82$) on the fish targets. Skewness of the fixation count values was 1.45, and log-transformation improved the values' skewness (skew = 0.62), therefore the log transformed values were used in the regression model. Table 4.28 shows the sequential models fitted to the data.

Table 4.28. Summary of the model selection process for the number of fixations on targets.

Model	Log-Likelihood	LR	<i>p</i>
Baseline	-730.87		
Target (FE)	-699.50	62.73	< .0001
Heteroscedasticity (Target)	-696.46	6.09	< .05
Covariance structure (Trial)	-693.03	6.85	< .01
Trial (FE)	-690.1	5.74	<i>ns</i>
Trial × Target	-691.05	3.97	<i>ns</i>
Anxiety	-692.95	0.16	<i>ns</i>
Anxiety × Trial	-692.68	0.70	<i>ns</i>
Anxiety × Target	-690.86	4.35	<i>ns</i>
Snake Phobia	-692.90	0.27	<i>ns</i>
Snake Phobia × Trial	-692.93	0.20	<i>ns</i>
Snake Phobia × Target	-692.64	0.79	<i>ns</i>
Target (random slopes across participants)	-686.59	12.89	< .05

The final model was a random intercept model with the fixed and random effects of target's threat level, in which both heteroscedasticity in the target threat level predictor, and covariance structure of trials were explicitly modelled. The parameters of this model are summarised in Table 4.29.

Table 4.29. Summary of the regression model predicting the targets fixation counts.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	0.3654	0.0367	1536	9.97	< .0001
Snake vs. Fish Targets	-0.0524	0.0090	1536	-5.85	< .0001
Threat Info vs. No Info Targets	0.0072	0.0152	1536	0.47	<i>ns</i>

There was a significant difference between the means of the trials with snake and fish targets, indicating that the participants fixated on the fish target images significantly more often than on the snake images. There was, however, no significant difference between the number of fixations on the threat information and no information snake images.

4.3.2.10. Summary of the target search task results

In the target search task, significant differences between the fear-irrelevant (fish) and the fear-relevant (snakes) targets were found for all the RT and eye movement indices. The participants RTs were significantly faster when detecting the snakes' images than the fish images. They fixated significantly faster on the snakes' images than the fish images, and in their first fixations dwelled for longer durations on the snakes' images than the fish images. In terms of the total dwell time on the target images in the task, dwell times were longer on the fish images than the snakes' images; however, the percentages of dwell time on the snakes' images were higher than the percentages of dwell time on the fish images. This discrepancy between the dwell time and dwell time percentage data indicates that the total dwell time in the trials with the snake targets were shorter than the trials with fish targets. This is because the trials with snake targets were terminated faster than the trials with fish target, which is consistent with the faster RTs for these trials. Finally, consistent with the dwell time results, the fish images were fixated more frequently than the snakes' images. For none of these indices was the difference between the threat information snake and the no information snake significant. Moreover, anxiety and snake phobia scores did not have any significant relationship with the RT and eye movement effects.

4.3.2.11. Target detection in the deviant search task: RT data

The RTs to detect the fear-relevant targets (snakes) among fear-irrelevant background (frog) images were faster than the RTs to detect the fear-irrelevant control targets (fish) among the background images. The mean RTs to detect the targets were as follows: 1141.70 ($SD = 425.64$) for the threat information snake; 1102.96 ($SD = 383.70$) for the no information snake; and 1179.66 ($SD = 421.48$) for the fish targets. Skewness of the RT values was 1.95, and log-transformation improved the values' skewness (skew = 0.66), therefore log-transformed values were used in the regression. Table 4.30 shows the sequential models fitted to the data. The final model was a random intercept model,

with the fixed effect of target's threat level, in which covariance structure of trials was explicitly modelled. The parameters of this model are summarised in Table 4.31.

Table 4.30. Summary of the model selection process for the RTs to detect the deviant targets.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	-120.63		
Target (FE)	-117.19	6.87	< .05
Heteroscedasticity (Target)	-115.61	3.17	<i>ns</i>
Covariance structure (Trial)	-111.60	11.20	< .0001
Trial (FE)	-110.33	2.52	<i>ns</i>
Trial \times Target	-110.87	1.45	<i>ns</i>
Anxiety	-111.33	0.53	<i>ns</i>
Anxiety \times Trial	-111.53	0.12	<i>ns</i>
Anxiety \times Target	-110.99	1.22	<i>ns</i>
Snake Phobia	-110.75	1.70	<i>ns</i>
Snake Phobia \times Trial	-109.99	3.21	<i>ns</i>
Snake Phobia \times Target	-110.66	1.87	<i>ns</i>
Target (random slopes across participants)	-109.98	3.22	<i>ns</i>

Table 4.31. Summary of the regression model predicting RTs to detect the deviant targets.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	6.9865	0.0297	767	235.19	< .0001
Snake vs. Fish Targets	-0.0150	0.0060	767	-2.52	< .05
Threat Info vs. No Info Targets	0.0117	0.0103	767	1.13	<i>ns</i>

There was a significant difference between the means of the trials with snake and fish targets, indicating that the participants detected the snake targets significantly faster than the fish targets among filler images. The mean RTs to detect threat information snake was not significantly different from the no information snake.

4.3.2.12. Target detection in the deviant search task: Time of the first fixation on the target

When displayed amongst fear-irrelevant background (frog) images, fear-irrelevant control target (fish) images were fixated faster than the fear-relevant target (snake) images. The mean first fixation times were as follows: 593.71 (*SD* = 277.96) for the threat information snake; 578.18 (*SD* = 261.86) for the no information snake; and

554.36 ($SD = 259.61$) for the fish images. Skewness of the first fixation time values was 2.17, and log-transformation improved the values' skewness (skew = 0.62), therefore log-transformed values were used in the regression. Table 4.32 shows the sequential models fitted to the data.

The final model was a random intercept model, with the fixed effect of the trial sequence, in which neither heteroscedasticity in the distractors' threat level predictor, nor covariance structure of trials, was modelled. The parameters of this model are summarised in Table 4.33.

Table 4.32. Summary of the model selection process for the first fixation times on deviant targets.

Model	Log-Likelihood	LR	<i>p</i>
Baseline	-317.43		
Target (FE)	-315.11	4.65	<i>ns</i>
Heteroscedasticity (Target)	-314.25	1.72	<i>ns</i>
Covariance structure (Trial)	-314.76	0.69	<i>ns</i>
Trial (FE)	-311.69	6.83	< .05
Trial × Target	-303.60	16.18	< .01
Anxiety	-302.56	2.10	<i>ns</i>
Anxiety × Trial	-302.20	2.81	<i>ns</i>
Anxiety × Target	-299.78	7.65	<i>ns</i>
Snake Phobia	-302.65	1.92	<i>ns</i>
Snake Phobia × Trial	-303.56	0.09	<i>ns</i>
Snake Phobia × Target	-301.57	4.08	<i>ns</i>
Target (random slopes across participants)	Failed to Converge	-	-

Table 4.33. Summary of the regression model predicting the first fixation times on deviant targets.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	6.6081	0.1795	700	36.82	< .0001
Snake vs. Fish Targets	-0.3670	0.1758	700	-2.09	< .05
Threat Info vs. No Info Targets	0.0690	0.0452	700	1.53	<i>ns</i>
Trial sequence – Linear trend	-11.8814	5.0533	700	-2.35	< .05
Trial sequence – Quadratic trend	3.7404	2.0068	700	1.86	<i>ns</i>

There was a significant difference between the means of the trials with snake and fish targets, indicating that the participants fixated significantly faster on the fish target

images relative to the snake target images. There was, however, no significant difference between the means of the first fixation time on the threat information and no information snakes.

4.3.2.13. Target detection in the deviant search task: Duration of the first fixation on the target

The first fixations lasted longer on the snake images than the fish images. The mean first fixation durations were as follows: 239.28 ($SD = 108.88$) for the threat information snake; 244.53 ($SD = 120.95$) for the no information snake; and 219.41 ($SD = 83.11$) for the fish images. Skewness of the first fixation duration values was 1.83, and log-transformation improved the values' skewness (skew = -0.19), therefore log-transformed values were used in the regression. Table 4.34 shows the sequential models fitted to the data.

Table 4.34. Summary of the model selection process for the duration of the first fixations on deviant targets.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	-395.82		
Target (FE)	-393.46	4.73	<i>ns</i>
Heteroscedasticity (Target)	-390.66	5.59	<i>ns</i>
Covariance structure (Trial)	-393.40	0.12	<i>ns</i>
Trial (FE)	-392.00	2.92	<i>ns</i>
Trial \times Target	-390.84	5.23	<i>ns</i>
Anxiety	-393.44	0.03	<i>ns</i>
Anxiety \times Trial	-393.26	0.39	<i>ns</i>
Anxiety \times Target	-392.86	1.18	<i>ns</i>
Snake Phobia	-391.94	3.04	<i>ns</i>
Snake Phobia \times Trial	-392.61	1.69	<i>ns</i>
Snake Phobia \times Target	-391.93	3.05	<i>ns</i>
Target (random slopes across participants)	Failed to Converge	-	-

The final model was a random intercept model, in which neither heteroscedasticity in the distractors' threat level predictor, nor covariance structure of trials, were modelled. The parameters of this model are summarised in Table 4.35.

Table 4.35. Summary of the regression model predicting first fixation durations on deviant targets.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	5.3672	0.0304	714	176.36	< .0001
Snake vs. Fish Targets	0.0218	0.0102	714	2.14	< .05
Threat Info vs. No Info Targets	-0.0063	0.0179	714	-0.36	<i>ns</i>

There was a significant difference between the means of the trials with snake and fish targets, indicating that the first fixation durations were significantly longer on the snake target images than the fish target images. There was, however, no significant difference between the durations of the first fixation on the threat information and no information snakes' images.

4.3.2.14. Target detection in the deviant search task: Dwell time on the target

The fish images were dwelt for longer times than the snake images. The mean dwell times were as follows: 342.77 (*SD* = 228.14) for the threat information snake; 341.17 (*SD* = 231.96) for the no information snake; and 356.96 (*SD* = 235.63) for the fish images was. Skewness of the dwell time values was 2.62, and log-transformation improved the values' skewness (skew = 0.25), therefore log-transformed values were used in the regression. Table 4.36 shows the sequential models fitted to the data.

The final model was a random intercept model, with the fixed effect of the trial sequence, in which neither heteroscedasticity in the distractors' threat level predictor, nor covariance structure of trials, were modelled. The parameters of this model are summarised in Table 4.37.

There was a significant difference between the means of the trials with snake and fish targets, indicating that the participants dwelt for significantly longer times on the fish images than the snake images. The difference between the dwell times on the threat information and no information snakes' images was not significant. Phobia score was a significant predictor of the dwell times on fish images. According to this effect, the participants higher in phobia scores dwelt for significantly shorter times on the fish images comparing with the participants who scored lower on the snake phobia scale.

Table 4.36. Summary of the model selection process for dwell times on deviant targets.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	-522.66		
Target (FE)	-521.83	1.66	<i>ns</i>
Heteroscedasticity (Target)	-521.19	1.28	<i>ns</i>
Covariance structure (Trial)	-521.66	0.33	<i>ns</i>
Trial (FE)	-518.74	6.18	< .05
Trial × Target	-517.54	2.39	<i>ns</i>
Anxiety	-518.62	0.24	<i>ns</i>
Anxiety × Trial	-517.98	1.51	<i>ns</i>
Anxiety × Target	-517.24	3.00	<i>ns</i>
Snake Phobia	-517.49	2.50	<i>ns</i>
Snake Phobia × Trial	-517.38	2.72	<i>ns</i>
Snake Phobia × Target	-514.64	8.20	< .05
Target (random slopes across participants)	Failed to Converge	-	-

Table 4.37. Summary of the regression model predicting dwell times on deviant targets.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	5.8072	0.0990	709	8.69	< .0001
Snake vs. Fish Targets	-0.0833	0.0314	709	-2.65	< .01
Threat Info vs. No Info Targets	-0.0320	0.0370	709	-0.87	<i>ns</i>
Trial sequence – Linear trend	-1.0846	0.9591	709	-1.13	<i>ns</i>
Trial sequence – Quadratic trend	-1.4204	0.5784	709	-2.46	< .05
No Info Snake × Phobia Score	-0.0116	0.0186	709	-0.63	<i>ns</i>
Threat Info Snake × Phobia Score	-0.0292	0.0188	709	-1.56	<i>ns</i>
Fish × Phobia Score	-0.0415	0.0186	709	-2.24	< .05

4.3.2.15. Target detection in the deviant search task: Percentage of dwell time on the target

The percentage of dwell time was higher on the threat information snake images than the other two targets. The means of the dwell time percentages were as follows: 0.3624 (*SD* = 0.1615) for the threat information snake; 0.3587 (*SD* = 0.1643) for the no information snake; and 0.3616 (*SD* = 0.1627) for the fish images. Skewness of the dwell time percentage values was 0.53, however, the log-transformation did not particularly improve the values' skewness (skew = -0.48), therefore, the non-transformed values

were used in the regression model. As seen above, the percentage of the dwell time on the fear-irrelevant target (fish), is lower than the percentages for the threat information snake, and higher than the percentages for the no information snake; therefore, the two snakes were not combined into one category (the fear-relevant target category), and the targets dwell time percentages were compared separately in two regression models. In the first model, the threat information snake is the baseline category. Table 4.38 shows the sequential models fitted to the data.

The final model was a random intercept model, in which neither heteroscedasticity in the distractors' threat level predictor, nor covariance structure of trials, were modelled. The parameters of this model are summarised in Table 4.39.

Table 4.38. Summary of the model selection process for the percentages of dwell times on deviant targets.

Model	Log-Likelihood	LR	<i>p</i>
Baseline	402.97		
Target (FE)	403.08	0.21	<i>ns</i>
Heteroscedasticity (Target)	403.35	0.54	<i>ns</i>
Covariance structure (Trial)	403.09	0.02	<i>ns</i>
Trial (FE)	405.60	5.05	<i>ns</i>
Trial \times Target	406.29	6.43	<i>ns</i>
Anxiety	403.68	1.20	<i>ns</i>
Anxiety \times Trial	403.93	1.70	<i>ns</i>
Anxiety \times Target	405.73	5.30	<i>ns</i>
Snake Phobia	403.27	0.37	<i>ns</i>
Snake Phobia \times Trial	403.35	0.55	<i>ns</i>
Snake Phobia \times Target	406.04	5.93	<i>ns</i>
Target (random slopes across participants)	Failed to Converge	-	-

Table 4.39. Summary of the regression model predicting the percentages of dwell times on the targets, with the threat information snake images as the baseline category.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	0.3593	0.0179	714	20.10	< .0001
No information snake target	-0.0039	0.0121	714	-0.32	<i>ns</i>
Fear-irrelevant (fish) target	0.0014	0.0120	714	0.12	<i>ns</i>

There was no significant difference between the baseline category (the threat information snake) and the two other target categories, indicating that the difference

between the percentages of the dwell time on the threat information snake images and on the no information snake and fish targets were not significant.

Another regression analysis was conducted to examine the significance of the difference between the percentages of the dwell time on the no information snake and fear-irrelevant (fish) target images. In this analysis the fear-irrelevant (fish) target is the baseline category. The relevant parameters of this regression analysis are reported in table 4.40 below.

Table 4.40. Summary of the regression model predicting the percentages of dwell times on the targets, with the fear-irrelevant targets as the baseline category.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
No information snake target	-0.0053	0.0120	714	-0.44	<i>ns</i>

The difference between the fear-irrelevant target category and the no information snake category was also non-significant, and in sum, there was not any significant difference in the dwell time percentages among the threat information snake, no information snake, and fish target images.

4.3.2.16. Target detection in the deviant search task: Number of fixations on the target

The fish images were fixated more often than the snake images. The mean fixation counts on the target images were as follows: 1.47 (*SD* = 0.84) for the threat information snake; 1.45 (*SD* = 0.80) for the no information snake; and 1.65 (*SD* = 0.87) for the fish images. Skewness of the fixation count values was 2.62, and log-transformation improved the values' skewness (skew = 1.03), therefore log-transformed values were used in the regression. Table 4.41 shows the sequential models fitted to the data.

The final model was a random intercept model, with the fixed effect of target's threat level, in which neither heteroscedasticity in the distractors' threat level predictor, nor the covariance structure of trials, were modelled. The parameters of this model are summarised in Table 4.42.

There was a significant difference between the means of the trials with snake and fish targets, indicating that the participants fixated significantly more frequently on the fish than the snake targets. However, the difference between the number of fixations on the threat information and no information snake images was not significant.

Table 4.41. Summary of the model selection process for the number of fixations on deviant targets.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	-374.94		
Target (FE)	-368.08	13.72	< .001
Heteroscedasticity (Target)	-367.17	1.82	<i>ns</i>
Covariance structure (Trial)	-368.06	0.03	<i>ns</i>
Trial (FE)	-367.30	1.55	<i>ns</i>
Trial × Target	-367.15	1.86	<i>ns</i>
Anxiety	-367.99	0.18	<i>ns</i>
Anxiety × Trial	-367.85	1.51	<i>ns</i>
Anxiety × Target	-365.71	4.72	<i>ns</i>
Snake Phobia	-367.75	0.65	<i>ns</i>
Snake Phobia × Trial	-367.80	0.55	<i>ns</i>
Snake Phobia × Target	-364.49	7.18	<i>ns</i>
Target (random slopes across participants)	Failed to Converge	-	-

Table 4.42. Summary of the regression model predicting fixation counts on the targets.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	0.3064	0.0388	714	7.90	< .0001
Snake vs. Fish Targets	-0.0360	0.0097	714	-3.71	< .001
Threat Info vs. No Info Targets	0.0037	0.0170	714	0.22	<i>ns</i>

4.3.2.17. Interference effect in the deviant search task: RT data

The RTs were slower when detecting the target (frog images) among fear-irrelevant control distractors (fish images) than the fear-relevant distractors (snake images). The mean RTs to detect the target amongst the fear-relevant and control distractors were as follows: 1116.81 (*SD* = 371.19) for the targets amongst the threat information snake distractors; 1097.80 (*SD* = 80.56) for the targets amongst the no information snake distractors; and 1227.08 (*SD* = 451.07) for the targets amongst the control distractors. Skewness of the RT values was 2.49, and log-transformation improved the values' skewness (skew = 0.66), therefore log-transformed values were used in the regression. Table 4.43 shows the sequential models fitted to the data.

The final model was a random intercept model, with the fixed effect of the distractors' threat level and trial sequence. The parameters of this model are summarised in Table 4.44.

Table 4.43. Summary of the model selection process for the RTs to detect the targets.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	-101.71		
Distractors (FE)	-89.43	24.58	< .0001
Heteroscedasticity (Distractors)	-89.06	0.73	<i>ns</i>
Covariance structure (Trial)	-88.61	1.62	<i>ns</i>
Trial (FE)	-85.36	8.13	< .05
Trial × Distractors	-82.99	4.74	<i>ns</i>
Anxiety	-85.23	0.26	<i>ns</i>
Anxiety × Trial	-84.34	2.04	<i>ns</i>
Anxiety × Distractors	-84.52	1.68	<i>ns</i>
Snake Phobia	-85.35	0.03	<i>ns</i>
Snake Phobia × Trial	-84.73	1.26	<i>ns</i>
Snake Phobia × Distractors	-84.72	1.27	<i>ns</i>
Distractors (random slopes across participants)	Failed to Converge	-	-

Table 4.44. Summary of the regression model predicting RTs to detect the targets.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	6.9971	0.0282	753	247.87	< .0001
Snake vs. Fish Distractors	-0.0496	0.0142	753	-3.48	< .001
Threat Info vs. No Info Distractors	0.0099	0.0112	753	0.89	<i>ns</i>
Trial sequence – Linear trend	-0.9698	0.5270	753	-1.84	<i>ns</i>
Trial sequence – Quadratic trend	0.2769	0.3271	753	0.85	<i>ns</i>

There was a significant difference between the means of the trials with snake and fish distractors, indicating that the participants detected the target significantly faster amongst the snake distractors than the control (fish) distractors. The mean RTs of the trials with threat information snake distractors was not significantly different from the means of the trials with no information snake distractors.

4.3.2.18. Interference effect in the deviant search task: The time of the first fixation on the target

Targets were fixated slower amongst the fear-irrelevant control (fish) distractors than fear-relevant (snake) distractors. The mean first fixation times on the target images amongst the fear-relevant and control distractors were as follows: 511.45 (*SD* = 182.73) for the targets amongst the threat information snake; 505.90 (*SD* = 193.95) for the targets amongst the no information snake was; and 595.14 (*SD* = 226.74) for the targets

amongst the fish images. Skewness of the first fixation time values was 1.73, and log-transformation improved the values' skewness (skew = 0.37), therefore log-transformed values were used in the regression. Table 4.45 shows the sequential models fitted to the data.

Table 4.45. Summary of the model selection process for the first fixation times on targets.

Model	Log-Likelihood	LR	p
Baseline	-246.91		
Distractors (FE)	-227.43	38.96	< .0001
Heteroscedasticity (Distractors)	-223.38	8.09	< .05
Covariance structure (Trial)	-222.31	2.15	<i>ns</i>
Trial (FE)	-217.31	12.16	< .01
Trial × Distractors	-213.43	7.76	<i>ns</i>
Anxiety	-217.26	0.10	<i>ns</i>
Anxiety × Trial	-216.43	1.74	<i>ns</i>
Anxiety × Distractors	-217.00	0.60	<i>ns</i>
Snake Phobia	-217.27	0.08	<i>ns</i>
Snake Phobia × Trial	-217.23	0.16	<i>ns</i>
Snake Phobia × Distractors	-217.25	0.12	<i>ns</i>
Distractors (random slopes across participants)	-217.31	-	-

The final model was a random intercept model, with the fixed effects of distractor's threat level and trial sequence, in which heteroscedasticity in the distractors' threat level predictor was explicitly modelled. The parameters of this model are summarised in Table 4.46.

Table 4.46. Summary of the regression model predicting the first fixation times on targets.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	6.2256	0.0235	755	265.04	< .0001
Snake vs. Fish Distractors	0.0040	0.0178	755	0.23	<i>ns</i>
Threat Info vs. No Info Distractors	0.0088	0.0129	755	0.68	<i>ns</i>
Trial sequence – Linear trend	2.0464	0.6508	755	3.14	< .01
Trial sequence – Quadratic trend	1.2867	0.4083	755	3.15	< .01

There was no significant difference between the first fixation times on the targets in trials with fear-relevant (snakes) and fear-irrelevant (fish) distractors. Similarly, there

was no significant difference between the first fixation times on the targets in trials with threat information snake and no information snake as distractors.

4.3.2.19. Interference effect in the deviant search task: Dwell times on distractors

Control distractor (fish) images were fixated for longer times than the fear-relevant distractor (snake) images. The mean dwell times on the distractor images were as follows: 71.43 ($SD = 160.53$) on the threat information snake; 67.60 ($SD = 147.87$) on the no information snake; and 77.88 ($SD = 154.12$) on the fish images. Skewness of the dwell time values was 3.24, and log-transformation improved the values' skewness ($skew = 1.08$), therefore log-transformed values were used in the regression. Table 4.47 shows the sequential models fitted to the data.

Table 4.47. Summary of the model selection process for dwell times on distractors.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	-15015.90		
Distractors (FE)	-15007.53	16.74	< .0001
Heteroscedasticity (Distractors)	-15004.72	5.62	<i>ns</i>
Trial (FE)	-15006.89	1.28	<i>ns</i>
Trial \times Distractors	-15006.60	1.87	<i>ns</i>
Anxiety	-15006.63	1.80	<i>ns</i>
Anxiety \times Trial	-15006.09	2.88	<i>ns</i>
Anxiety \times Distractors	-15006.57	1.93	<i>ns</i>
Snake Phobia	-15007.28	0.50	<i>ns</i>
Snake Phobia \times Trial	-15007.39	0.29	<i>ns</i>
Snake Phobia \times Distractors	-15007.28	0.51	<i>ns</i>
Distractors (random slopes across participants)	-15007.53	-	-

The final model was a random intercept model, with the fixed effect of distractor's threat level. The parameters of this model are summarised in Table 4.48.

Table 4.48. Summary of the regression model predicting dwell times on distractors.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	1.4671	0.0458	6492	32.05	< .0001
Snake vs. Fish Distractors	-0.0860	0.0211	6492	-4.08	< .0001
Threat Info vs. No Info Distractors	0.0109	0.0365	6492	0.30	<i>ns</i>

The difference between the dwell times on the fear-relevant and control distractors was significant, indicating that the control distractors (fish images) were fixated for longer times compared to the fear-relevant distractors (snake images). There was no significant difference between the dwell times on the threat information and no information snake images.

4.3.2.20. Interference effect in the deviant search task: Percentage of dwell time on distractors

The percentage of dwell time was higher on the control distractor (fish) images than the fear-relevant distractor images. The mean dwell time percentages for the distractor images were as follows: 0.0759 ($SD = 0.1609$) for the threat information snake distractors; 0.0735 ($SD = 0.1557$) for the no information snake distractors; and 0.0779 ($SD = 0.1522$) for the control distractors' images. Skewness of the dwell time percentage values was 2.43, but the log-transformation did not improve the values' skewness notably (skew = 2.11), therefore the non-transformed values were used in the regression analysis. Table 4.49 shows the sequential models fitted to the data.

Table 4.49. Summary of the model selection process for the percentages of dwell times on distractors.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	2852.33		
Distractors (FE)	2852.77	0.88	<i>ns</i>
Heteroscedasticity (Distractors)	2856.18	6.81	< .05
Trial (FE)	2856.54	0.73	<i>ns</i>
Trial \times Distractors	2856.64	0.92	<i>ns</i>
Anxiety	2857.04	1.72	<i>ns</i>
Anxiety \times Trial	2856.62	0.89	<i>ns</i>
Anxiety \times Distractors	2857.71	3.06	<i>ns</i>
Snake Phobia	2856.67	0.98	<i>ns</i>
Snake Phobia \times Trial	2856.73	1.10	<i>ns</i>
Snake Phobia \times Distractors	2856.75	1.15	<i>ns</i>
Distractors (random slopes across participants)	2856.18	-	-

The final model was a random intercept model in which heteroscedasticity in the distractors' threat level predictor was explicitly modelled. The parameters of this model are summarised in Table 4.50.

Table 4.50. Summary of the regression model predicting the percentages of dwell time on distractors.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	0.0758	0.0020	6492	38.02	< .0001
Snake vs. Fish Distractors	-0.0011	0.0014	6492	-0.80	<i>ns</i>
Threat Info vs. No Info Distractors	0.0012	0.0024	6492	0.50	<i>ns</i>

The difference between the percentages of dwell times on the fear-relevant and control distractors was not significant. Similarly, there was no significant difference between the percentages of dwell time on the threat information and no information snake images.

4.3.2.21. Interference effect in the deviant search task: Number of fixations on distractors

The control distractor (fish) images were fixated more often than the snake images. The mean fixation counts on the target images were as follows: 0.3576 (*SD* = 0.7079) on the threat information snake; 0.3396 (*SD* = 0.6567) on the no information snake; and 0.4159 (*SD* = 0.7254) on the fish images. Skewness of the fixation count values was 2.31, and log-transformation improved the values' skewness (*skew* = 1.42), therefore log-transformed values were used in the regression. Table 4.51 shows the sequential models fitted to the data.

Table 4.51. Summary of the model selection process for fixation counts on distractors.

Model	Log-Likelihood	<i>LR</i>	<i>p</i>
Baseline	-3077.52		
Distractors (FE)	-3068.98	17.07	< .0001
Heteroscedasticity (Distractors)	-3063.61	10.73	< .01
Trial (FE)	-3062.97	1.30	<i>ns</i>
Trial × Distractors	-3062.79	1.64	<i>ns</i>
Anxiety	-3063.30	0.62	<i>ns</i>
Anxiety × Trial	-3063.01	1.22	<i>ns</i>
Anxiety × Distractors	-3063.22	0.78	<i>ns</i>
Snake Phobia	-3063.15	0.94	<i>ns</i>
Snake Phobia × Trial	-3063.28	0.67	<i>ns</i>
Snake Phobia × Distractors	-3063.12	0.98	<i>ns</i>
Distractors (random slopes across participants)	-3063.61	-	-

The final model was a random intercept model, with the fixed effect of distractor's threat level, in which heteroscedasticity in the distractor's threat level predictor was explicitly modelled. The parameters of this model are summarised in Table 4.52.

Table 4.52. Summary of the regression model predicting fixation counts on distractors.

	<i>b</i>	<i>SE b</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	0.2261	0.0069	6492	32.66	< .0001
Snake vs. Fish Targets	-0.0139	0.0034	6492	-4.02	< .0001
Threat Info vs. No Info Targets	0.0033	0.0057	6492	0.58	<i>ns</i>

There was a significant difference between the control (fish) and snake distractors, indicating that the control distractor images were fixated more frequently than the snake distractor images. Similar to the previous indices, there was no significant difference between the number of fixations on the threat information and no information snakes images.

4.3.2.22. Summary of the deviant search task results

In analyzing the deviant search task results, the differences between fear-relevant and fear-irrelevant stimuli were compared in two parts. In the first part, the findings related to the detection of the fear-relevant and fear-irrelevant targets, and in the second part, the findings related to the interference effect of the fear-relevant and fear-irrelevant stimuli (when presented massively as distractors) were analyzed.

The findings of the target detection condition, consistent with the other search task of this experiment (the target search task), showed that RTs were significantly faster when detecting the fear-relevant (snake) targets than the fear-irrelevant control (fish) targets. In contrary to the RTs findings and to the findings of the target search task, the first fixation times were significantly faster on the control targets than the fear-relevant targets. Moreover, in this condition similar to the target search task, the first fixation durations were significantly longer on the fear-relevant targets than the control targets. In this condition, similar to the previous search task, the total dwell times and the number of fixations were also significantly higher on the control targets than the fear-relevant targets. Unlike the target search task, however, in this condition of deviant

search task, there was no significant difference between the percentages of dwell time on the control and fear-relevant targets.

The results of the interference condition of the deviant search task showed that the participants had significantly slower RTs when detecting the fear-irrelevant (frog) targets among fear-irrelevant control (fish) distractors relative to the fear-relevant (snake) distractors, although the differences between the first fixations on the targets among the fear-relevant and the control distractors were not significant. Moreover, similar to the previous task of this condition, the control distractors were dwelt for longer times compared to the fear-relevant distractors; the control distractors were fixated more frequently than the fear-relevant distractors; and there was no significant difference between the control and fear-relevant distractors in terms of dwell time percentages.

In none of the conditions was a significant difference found between the means of the threat information and no information snakes. Finally, anxiety and snake phobia scores did not have any significant effect on the RT and eye movement responses, except for an effect of snake phobia scores on the duration of dwelling on the fear-irrelevant control targets.

4.3.3. Discussion

4.3.3.1. Fear beliefs

In the current experiment, the effect of threat information on fear acquisition was measured using the snake fear beliefs questionnaire. This scale was administered before and after giving the information about one of the snakes whose images were used in the visual search tasks. The fear beliefs scores of both threat information and no information snakes in baseline and post-test measurements were compared, and the results showed a significant increase in fear beliefs in post-test measurements for both types of snakes.

Therefore, the first hypothesis of this experiment is supported, which is consistent with the previous research on fear induction through indirect fear acquisition pathways. This includes the research conducted by Field and his colleagues (e.g., Askew & Field, 2007; Field & Lawson, 2003) who induced fear of novel animals through informational and vicarious learning pathways; Rapee and his colleagues (e.g., Gerull & Rapee, 2002) who induced fear of fear-relevant animals in toddlers through vicarious learning; and

Mineka and her colleagues (e.g., Cook & Mineka, 1989, 1990) who induced such fears through vicarious learning in lab-reared monkey.

It should be noted that the increase in fear beliefs was not specific to the threat information stimulus, and fear beliefs of the no information snake also significantly increased in the post-test. However, the increase was more salient for the threat information snake: while in baseline measurement, the participants' fear beliefs scores were significantly higher for the no information snake than the threat information snake, after receiving the threat information, it was the fear beliefs scores for the threat information stimulus which were significantly higher than the fear beliefs scores for the no information stimulus. It was, therefore, assumed that such difference in fear responses to the threat information stimulus relative to the no information stimulus would also be reflected in the attention deployment responses to the stimuli in the search tasks.

As mentioned before, this is the first study, to our knowledge, which has attempted to induce fear and attentional bias through informational learning in adults. Such fear and attentional bias induction by giving threat information has already been conducted in children (e.g., Askew & Field, 2007; Field & Lawson, 2003; and the experiments of the previous chapter of the present thesis), although with a major difference. In the studies conducted on children, the stimuli about which threat information was given were novel stimuli, that is, Australian marsupials. In the experiments of the current chapter, however, adults received threat information about one of the most commonly feared stimuli, that is, snakes. As discussed in the introduction section of the present chapter, the main reason of this change was the novelty assumption made in the child studies, which could not be realistic for the adult samples used in the current chapter's experiments. Therefore, instead of receiving threat information about novel animals, adults were given threat information about fear-relevant animals, because it was assumed that threat information would be most believable for adults when the information is about this type of stimuli. The self-reported fear beliefs results, supported this assumption and showed that fear of fear-relevant animals was increased after receiving the information, which was similar to the increase of fear of novel animals due to receiving threat information in the aforementioned child studies.

There is, however, a difference between the current study and the aforementioned studies in their fear evaluation methods. In the current study, the only index of fear acquisition was the self-reported fear beliefs, whereas in the other studies, behavioural

reactions to the newly feared stimulus, alone or in combination with the other fear response indices, have been measured to assess the acquired fear. In the current experiment, it is possible that the elevation in the post-test fear beliefs scores is due to the participants' conformity with the demand characteristics of the test. A more thorough fear assessment, therefore, can be helpful to ensure the validity of the assessment. Measuring the participants' behavioural avoidance or physiological responses when encountering the stimuli, or measuring their implicit cognitions, for instance by the Implicit Association Task (Greenwald, et al., 1998), can be useful in examining whether receiving threat information leads to increasing the fear of fear-relevant stimuli. A more comprehensive fear measurement was not possible in the current experiment as the focus of the experiment was on the visual attentional responses to the threat stimuli.

4.3.3.2. Attentional bias

The results of both search tasks showed evidence of attentional bias towards snake stimuli, but little evidence for the effect of threat information on attentional bias and attention deployment patterns.

In the target search task, the snake targets were detected faster than the fear-irrelevant (fish) targets, and the effect was found in both RT and first fixation time results. These results indicate that when the instruction was to search for a pre-specified target, in other words, when the search was based on a "top-down" process, the snake images could be identified more efficiently than the fish images from the background fear-irrelevant animal images. The fast identification of the snake images can be because of their assumed emotional salience and fear-relevance. It can also be due to inevitable feature distinctions between snakes and fish images, which made identifying the snakes' images from the background images easier than identifying the fish images from the background images. The previous research has yielded mixed results when using the target search design. In Rinck et al.'s (2005) study no attentional bias toward the snake target images was found, but in LoBue & DeLoache's (2008) study both children and adults had faster RTs when detecting snake target images compared to flower, frog, and caterpillar target images.

Most of the previous visual search studies on this topic have employed the deviant search design. Although the stimulus arrays in both target search and deviant search tasks can be identical, the instructions of the two tasks are assumed to tap fundamentally

different search processes, that is, “bottom-up” search process is elicited by the instruction of the deviant search task. In the deviant search task of the present experiment also evidence of attentional bias towards fear-relevant images was found, and in general, the similar results as to the findings of the target search task were found. In both tasks, RTs to detect the snake targets were significantly faster than the control (fish) targets. Moreover, the first fixations were significantly longer on the snake targets than the control (fish) targets. This can be interpreted as evidence of the automatic “freezing response” when encountering fear-relevant stimuli (e.g., Fox, et al., 2001). Finally, dwell times and fixation counts follow similar patterns in both tasks, that is, the means of both indices were significantly higher for the fish images than the snake images.

There are some differences in the findings of the target search task and the target detection condition of the deviant search task. In the target search task, contrary to the pattern of higher gaze durations and fixation counts on the control targets than the fear-relevant targets, the percentages of dwell time were higher on the fear-relevant targets than the control targets. This is explicable by noticing the RTs to the trials with snake targets. The faster RTs in these trials mean that these trials were terminated earlier relative to the trials with fish targets. Therefore, the proportions of the dwell time on the snake targets in the relevant trials is higher than these proportions for the fish targets in the relevant trials, although the total dwell time on the snake targets is lower than the total dwell times on the fish targets. This effect was not repeated in the target detection part of the deviant search task, thus, in this task there was no significant difference between the percentages of dwell time on the snake and fish target images. In general, in both target search task and target detection condition of the deviant search task, the participants fixated for longer times and more frequently on control targets than the snake targets, before specifying their presence in the stimulus arrays by making the manual response. This longer dwell time and more frequent fixations on control targets can be due to the fish targets needing more time to be processed. Another possible explanation for these effects can be that the fish images were perceived as safe stimuli and were not avoided, whereas the snake targets were avoided.

The more important difference between the two tasks results pertains to the interesting interaction of the first fixation times on the targets and the RTs to detect the targets. While in the target search task the first fixation times were significantly faster on the fear-relevant targets than the control targets; in the deviant search task, first

fixation times were significantly faster on the control targets than the snake targets, but in both tasks the RTs were significantly faster when detecting the snake targets than the control targets.

This difference might be because of the different processes involved in the two tasks. In the target search task, the participants searched for two specific targets that they were instructed to, that is, fish and snake. When this top-down process was involved, they both first fixated and responded more quickly to the fear-relevant targets. These fast fixations on, and RTs to, the fear-relevant targets can be due to the emotional salience of the snake images, or alternatively, it can be due to the distinctions of the images' features from the background images. However, in the deviant search task, no specific target is specified and the search is assumed to be bottom-up. This presumably means that detecting the deviant image relies more on the features distinctions of the deviant image and the background images. It was found in this task, unlike the target search task, that the fish images were fixated faster than the snake images. This can imply that the distinction between the fish images and the background images was more pronounced than the distinction between the snake images and the background images. Despite this possible higher distinction of the fish and background images (inferred from the faster fixations on the fish deviant images than the snake deviant images), the RTs to detect the snake targets were faster than the RTs to detect the fish targets. This implies that snake images were processed significantly faster than the fish images, so that the fast processing time has even filled the gap of a later fixation on the snake images relative to the fish images and led to the faster RTs. This interaction also confirms that the faster RTs to detect the snake targets than the fish targets was not due to the higher distinction of the features of the snake targets and the background images than the distinction of the fish targets and the background images, at least in the deviant search task. It is worth noting that because the background images of the deviant and target search tasks are not identical, there is still a possibility that the faster first fixations on the snake targets, and faster RTs to detect the targets, than the fish targets in the previous task (the target search task), might be due to the higher features distinctions of the snake targets than the fish targets from the background images. However, this can be ruled out for the deviant search task, and it can be concluded that the faster RTs to detect the snake images than the fish images is due to faster processing of the snake targets.

The results of the interference condition of the deviant search task show that the target images were fixated and detected faster amongst the fear-relevant (snake) distractors than the control (fish) distractors. Therefore, the predicted interference effect of the fear-relevant images was not found.

As discussed above this cannot be attributed to difference between the distinctions of the snake and frog images and the distinctions of fish and frog images, and there needs to be another explanation for the faster detection of frog targets among snake distractors than fish distractors. A possible explanation for this effect can be avoidance of the snake images. Such avoidance might have stimulated the participants to shorten their search on the snake images, by finding the safe part of the stimulus arrays, which in these trials was the frog's grid location, and/or by responding to the trials which led to terminating the trial's stimuli presentation. This interpretation is supported by the results of the other indices of this task. Dwell time, and the number of fixations were significantly higher on the fish images than the snake images. This can be because of avoiding the threatening snake images.

Faster detection of fear-relevant than fear-irrelevant control targets in the target search conditions of this experiment is consistent with the predictions and with most of the previous studies (Öhman, Flykt, et al., 2001; Miltner, et al., 2004; LoBue & DeLoache, 2008; Soares, Esteves, Lundqvist, et al., 2009). There are some exceptions in the previous studies, for instance, in a study by Soares, Esteves, and Flykt (2009, Experiment 1) when using animals as both targets and distractors in the stimulus arrays, the faster detection of fear-relevant animals were not found. In other odd-one-out search studies (e.g., Lipp, et al., 2004), this effect was found only when the fillers were from different categories, namely flower and mushroom. The present experiment provides more evidence for the existence of the attentional bias towards fear-relevant animals even when animal images are used as fillers in the stimulus arrays.

In the present experiment, despite the mass presentation of the fear-relevant distractors in the stimulus arrays, no interference effect was found. The snake images neither delayed detecting the targets nor were fixated for longer durations. The fear-irrelevant targets were even detected faster among snake distractors than the control distractor. This is inconsistent with previous studies that have found the interference effect by the fear-relevant images, including snake images, in massive presentations of the distractors (Miltner, et al., 2004; Rinck, et al., 2005; Lipp, 2006, Experiment 2) . The shorter gaze durations on snake distractors than the control distractor in the current

experiment is also inconsistent with the results found by Rinck et al. (2005). In their study, spider fearful participants, relative to the non-fearful control participants, dwelled for longer durations on spider distractors in an odd-one-out search task.

Nonetheless, in the current experiment, faster detections of, and longer first fixation durations on, snake images in the beginning of the search, and a later shorter dwell times on these images as compared to the control targets seem to be consistent with a pattern of vigilance-avoidance. If this is the case, the results of the current experiment is in line with a number of studies in which a hypervigilance-avoidance attentional pattern has been found in spider phobic and spider anxious participants when searching in different types of stimulus arrays containing spider images (Rinck & Becker, 2006; Hermans, et al., 1999; Pflugshaupt, et al., 2005). In the studies in which the hypervigilance-avoidance pattern was found, the interference effect of the spider images was not investigated, and in the only eye-tracked odd-one-out search task in which fear-relevant animal stimuli were used (i.e., Rinck, et al., 2005), both fast detection of, and distraction by, fear-relevant (spider) stimuli for spider phobics was found. In Rinck et al.'s study, however, not only spider phobic did not avoid, more than the non-phobics, the spider images which were displayed massively in the stimulus arrays, but they even dwelled for longer times than the non-phobic participants on the spider images. The current experiment results seems to be more consistent with the studies which found the vigilance-avoidance pattern, rather than the results of Rinck et al.'s (2005) study. If the shorter dwell times on snake distractors compared to the control distractors are due to the avoidance of snake images, such avoidance also might have influenced target detection time and accelerated this response.

In sum, two possible explanations for the pattern of results found in the distraction condition of the deviant search task can be considered. The first possibility is that the specifications of the images of the snakes, fish, and frogs images were somehow that frog target images were recognised faster among snake images than among fish images, and snake target images were recognised faster than fish target images among frog images. Even if this was the reason, it was not because snake images attracted the involuntary attention more than the fish images in the frog images background (as seen before, the fish images were actually fixated faster than the snake images among the frog images), but due to some other image qualities that made the recognition of the snake from the frog images easier than the fish from the frog images.

The other possible explanation for the response pattern found in the interference condition of the odd-one-out search task (i.e., the shorter dwell times on the fear-relevant images as compared to fear-irrelevant ones, in addition to the faster detection of the targets when displayed amongst the fear-relevant distractors as compared to the fear-irrelevant ones) is the avoidance of snake distractors. As discussed before, a vigilance effect when attending to snake images was also found in the other conditions of this experiment's search tasks. These were the target search task, and the target search condition of the odd-one out search task, in both of which the snake targets were detected faster than the fear-irrelevant control targets. Therefore, if we accept the existence of an avoidance response pattern in the interference condition of the odd-one out search task, the current experiment's findings may generally be indicating a pattern of vigilance-avoidance when attending to snake images. Such a vigilance-avoidance pattern has been reported in phobic individuals (e.g., Pflugshaupt, et al., 2005), but because the participants of this experiment initially had low snake phobia scores, the existence of such pattern might not be expected to be found in them. The special situations of this study, that is, listening to threat information about one of the snakes might have contributed to the possible occurrence of the vigilance-avoidance responses. It is possible that the threat information might have been generalised to both snakes and increased the general level of snake fear, and consequently has led to the vigilance-avoidance responses towards the snake stimuli.

This is, however, only a possibility, and no clear evidence was found in the results for the main hypothesis of this experiment, that is, the effect of threat information on the patterns of visual attention towards fear-relevant animals. Although the snake fear beliefs results showed a significant difference between the threat information and no information snakes, this difference was not reflected in the RT and eye movement indices results. As mentioned before the significant differences found in the fear beliefs results might be due to demand characteristics, and it might be the case that no actual increase in the participants fear beliefs about the threat information snake has occurred because of listening to the threat information. Another possibility is that the acquisition of fear of threat information snake has occurred, but the attentional bias paradigms employed were not sensitive enough to gauge the effect. Using other visual search paradigms that elicit more active search efforts, such as finding hidden targets, or presenting smaller stimuli in higher numbers might also help in gauging a possible bias effect.

In sum the current experiment showed clear evidence of attentional bias to snake images with some novel findings, such as longer first fixation durations which resemble a freeze response when encountering dangerous stimuli, and signs of hypervigilance-avoidance scanpaths pattern. However, it failed to find evidence for the effect of threat information about fear-relevant stimuli on the patterns of attention toward the stimuli.

4.4. Summary

In two experiments of this chapter, attentional bias towards snake images and the effect of fear induction through indirect pathway of informational learning on the attention deployment patterns were examined. Attentional bias towards the images of the threat information and no information snakes was examined in three tasks in two experiments. The tasks were designed to examine two main attentional bias effects, threat interference, and threat detection effects.

In terms of threat interference effect, in the first experiment it was examined whether the presence of a single image of snake in the stimulus array distracts participants of their task to detect a fear-irrelevant control target. This effect was not found: neither the participants' RTs to detect the target, nor their first fixation times on the target, were delayed by the snakes' image. They also did not fixate first on the snake distractors more frequently than fixating first on the targets. In another search task, that is, the odd-one-out task, in the second experiment, mass presentation of snake images not only did not delay the detection of deviant (fear-irrelevant) images, it even speeded the detections. A pattern of avoidance of the snake images was inferred from this task's results, and it was argued that the faster detection of deviant targets in the trials with snake distractors as compared to the trials with control (fear-irrelevant) distractors, might be related to such an avoidance effect. Based on this argument, it is possible that avoiding the snake images in these trials, which were presented in all the matrix grid locations except the deviant image, and striving to terminate the search on the snake images led to fixating faster on the deviant image. This argument can also be supported by shorter dwell times on the snake distractors as compared to the control distractor

images. There were also some signs of avoiding snake images in the first experiment results which in line with the existence of such avoidance effect.

Although the distraction effect was not found in either of the experiments, strong evidence was found for efficient detection of snake images indexed by RTs in both target detection tasks (the target search task, and the target detection condition of the odd-one-out search task) in the second experiment. An interaction between RTs and first fixation times was found when detecting the fear-relevant (snake) and the control (fish) targets among fear-irrelevant (frog) background images in the deviant search task, based on which fish targets were fixated faster than snake targets, but the RTs to snake targets were faster than the RTs to fish targets. This suggests that the origin of fear-relevant attentional bias can be the more efficient processing of threat related images rather than faster automatic gaze directions to the images. To keep the discussion concise and avoid repetition, further discussions on the findings of these two experiments will be presented in the next chapter.

Chapter 5: General Discussion

The main aims of this thesis were: (a) to examine the specifications of the visual scanpaths patterns when attending to newly feared stimuli, as compared to the patterns related to non-feared stimuli and naturally occurring threat stimuli; and (b) to examine the possibility that threat information could enhance the perceived threat of fear-relevant animals, and if this manipulation would lead to enhanced attentional bias effects. This discussion chapter is presented in four sections. In the first section, the findings of the present thesis research pertaining to the acquired attentional bias towards novel animals are discussed. In the second section, the findings pertaining to the effect of threat information in enhancing the fear of, and attentional bias towards, fear-relevant animals are discussed. In the third section, the naturally occurring and the induced threat related attentional biases are contrasted. Finally in the fourth section, the implications of the current research results and the research limitations are discussed and some suggestions for the future research are made.

5.1. Acquiring fear and attentional bias of novel stimuli

5.1.1. Learning fear of novel stimuli

Two experiments of Chapter 3 replicated the effect that verbal threat information increases children's fear beliefs of a novel animal, which has been repeatedly shown in previous research employing Field's threat information paradigm (Field & Lawson, 2003). In the second experiment of Chapter 3, the fear beliefs of the animal about which no information was given also significantly increased. Based on the previous experiments in which the FBQ paradigm was employed, a slight increase in the fear beliefs scores for the no information animal, rather than a significant one, would have been expected (as was found in the first experiment of this chapter). Nonetheless, the fear beliefs scores for the threat information animal were significantly higher than the ones of the no information animal after receiving the information in both experiments, indicating that more self-reported fear was acquired for the threat information animal than the no information one. Therefore, it was assumed that the threat information animal was more feared than the control and this relatively greater fear would be

reflected in the attention deployment to the animal's images. This assumption was supported, to some extent, in both experiments.

5.1.2. Acquiring attentional bias toward novel stimuli

Two different attentional bias effects were found in two experiments of Chapter 3 indicating that attentional bias was also acquired after learning to fear a novel animal (see Table 5.1. for a summary of the results of the search tasks conducted in the experiments of this thesis). In the first experiment, the bias was demonstrated as interference effects. The presence of the threat information animal image was associated with significant delays in RTs to detect a familiar fear-irrelevant target, and in the first fixations on the target, compared to when the no information animal images were presented in the stimulus arrays as distractors. Moreover, threat information animal images attracted more uninstructed saccades than the no information animal images when detecting the target in the stimulus arrays. All these effects showed that the images of the newly feared animals distracted the participants and interfered in target detection.

In the second experiment, the attentional bias was demonstrated as a faster target detection effect. In the previous research, similar faster RTs indicating attentional bias toward a newly feared animal were found using the dot probe (Field, 2006c, 2006a) and visual search task (Field, et al., 2009). This RT effect was replicated in the second experiment of Chapter 3. In this experiment, similar to Field, et al.'s (2009) study, the participants had significantly faster RTs when detecting the threat than the control targets hidden in naturalistic jungle scenes. Therefore, the acquisition of attentional bias through the informational learning pathway was confirmed by both experiments' results.

Table 5.1. Summary of the findings of the visual search tasks.

Experiment and search task	RT findings	Eye movement findings	Interpretations of the findings
Experiment 1: target search task, Threat and control stimuli were used as targets.	Faster RTs to angry than happy and neutral facial expressions, and no difference between happy and neutral faces. Anxious children decided significantly faster than non-anxious whether angry faces were present or absent compared to neutral faces*.	Angry facial expressions were fixated faster than the other two facial expressions. Results of the first fixation durations and dwell time indices mixed but generally supportive of the threat prioritisation predictions.	Threat related biases indicated by both RT and eye movement effects in all participants
Experiment 2: target search task with the interference design, Threat information and no information stimuli used as distractors.	Presence of threat information distractor delayed the RTs to detect targets.	The presence of threat information distractor delayed first fixations on targets. Threat distractors were fixated more frequently than control distractors before targets. No difference between threat and no information distractors in terms of eye movement indices.	Acquisition of fear and attentional bias of novel stimuli. Bias effects in both RT and eye movement results, but limited only to interference effect.
Experiment 3: target search task, threat and no information stimuli displayed as targets hidden in jungle images.	Faster RTs when detecting threat than control targets	No difference between threat and control targets in terms of eye movement indices	Acquisition of fear and attentional bias of novel stimuli. Bias effects limited to faster RTs.
Experiment 4: target search task with interference design. Fear-relevant (threat and no information) stimuli, and fear-irrelevant control	The presence of fear-relevant distractors (snake images) did not cause any significant delay in the RTs to detect fear-irrelevant targets	No delay in first fixations on targets caused by fear-relevant distractors. Faster first fixations on threat information snakes than on no information snakes	No interference effect of fear-relevant distractors on RTs and overt attentional responses. Little evidence of enhanced bias effect

stimuli used as distractors.		and control stimuli**. Signs of shorter gaze dwelling on fear-relevant distractors.	due to receiving threat information.
Experiment 5 – target detection task. Fear-relevant (threat and no information) stimuli, and fear-irrelevant control stimuli used as targets.	Faster RTs to fear-relevant targets than control targets. No significant difference between the RTs to threat information and no information fear-relevant targets.	Faster and longer first fixations on fear-relevant targets than control targets. Shorter gaze dwelling on fear-relevant targets than control targets. No significant difference between threat and no information targets.	Clear evidence of fast detection of fear-relevant stimuli in RTs and eye movement results. No evidence of enhanced bias effect due to receiving threat information.
Experiment 5 – odd-one-out search task – threat detection condition. Fear-relevant (threat information and no information) stimuli, and fear-irrelevant control stimuli used as deviant targets.	Faster RTs to fear-relevant targets than to control targets. No significant difference between threat information and no information fear-relevant targets.	Faster first fixations on control than fear-relevant targets. Longer first fixations on fear-relevant than control targets. Less dwelling on fear-relevant than control targets in the total stimuli display times. No significant difference between threat and no information targets.	Evidence of attentional bias to fear-relevant stimuli indicated only by faster RTs to detect fear-relevant targets. No evidence of enhanced bias effect due to receiving threat information.
Experiment 5 – the odd-one-out search task – distraction by threat condition. Fear-relevant (threat and no information) stimuli, and control stimuli massively presented as distractors.	No delay in RTs by mass presentation of distractors. Even faster RTs to targets displayed amongst the fear-relevant than the fear-irrelevant control distractors. No significant difference between threat and no information targets.	Faster first fixations on targets displayed amongst fear-relevant than control distractors. Less dwelling on fear-relevant than control distractors. No significant difference between threat and no information targets.	No evidence of threat interference effect. Shorter dwelling on fear-relevant animal images which might imply on an avoidance effect.

*This was the only significant interaction effect found between the participants' trait anxiety scores and the attentional bias indices' results in the experiments of this thesis. Moreover, no significant interaction

of snake phobia scores and attentional bias toward fear-relevant (snake) stimuli was found in the fourth and fifth experiments.

**This was the only notable effect of threat information on attentional bias indices found in the adult studies of this thesis (fourth and fifth experiments).

5.1.3. Specifications of the patterns of attention deployment to newly feared stimuli

In the first experiment of Chapter 3, the difference between the attention deployment to the threat information and no information animal images was limited to the interference effect of the threat information animal image. As mentioned above, this effect was indicated by delays in fixating the target, and by uninstructed saccades to the threat information animal images. No other noteworthy difference was found between the threat information and no information animal images in terms of the eye movement indices. Contrary to the predictions based on the previous threat-related attentional bias studies, the threat information animal images were not fixated faster, were not dwelt on for longer times, and the first fixation on them did not last longer compared to the control animal images.

There are two possibilities for not finding any difference in overt attention allocation to the threat and control stimuli in this experiment. First, it might be the case that threat related attentional bias responses have different levels. One of these levels might be how threat stimuli are processed, which is indicated by RT measures. The other level might be the overt attentional deployment, as indicated by measures such as fast fixation, prolonged dwelling, and the vigilant-avoidant response pattern. Based on this argument, different types of threat stimuli might elicit different levels of the bias responses. In the case of this experiment, the newly feared stimuli only elicited differential processing effects, but not the overt attention allocation effects. As reviewed before, the overt attentional responses have been found in the previous research for naturally occurring biases (e.g., phobia and anxiety related biases). Therefore, it might be the case that these effects are specific to the well-established fears, and do not emerge soon after fear of a stimulus is acquired. In other words, it is possible that overt attention allocation effects are specific to the *severity* of the fear.

It needs to be mentioned that these conclusion is inferred by comparing the results of studies in which different methods, stimuli and participants have been used. The

inferences, therefore, should be considered as possibilities that need to be validated by further research, rather than firm conclusions. The issue of using diverse methods, stimuli and participants in the studies of this thesis have been discussed in the limitation section of this chapter.

The second possibility is that the interference task used in the experiment might not be optimal for detecting overt attentional deployment effects. In this experiment, the interference task detected only the interference effect caused by threat stimuli, but no direct attentional deployment to the threat stimuli. It is possible that such effects were indeed displayed by the participants but the task employed failed to register them. If this was the case, the interference visual search task, as an attentional bias test, did not display the expected effects. In other words, the task might have lacked criterion validity, that is, it did not measure what it intended to measure (Field, 2009). The design of the interference task is similar to the task used in Miltner et al.'s (2004) study. In this study distraction effects similar to what was found in the current research experiment were caused by spider images in adult spider phobics. In Miltner et al.'s paper, however, only the eye movement indices that were related to the interference effect were reported, and the differences in direct attention deployment to the threat related distractors (spider images) and control distractors (mushroom images) were not reported. It is likely that no significant difference in the overt attention allocation responses to the threat and control distractors was found in Miltner et al.'s study either. The instruction and configuration in the stimulus arrays of this type of search task do not require participants to fixate the distractor image before the target. In many cases, thus, they will fixate the target image without fixating the distractors. The significantly slower RTs in the distractor present trials, as compared to the trial in which the distractor was not displayed, indicate that the distractor has been perceived even if it has not been fixated. However, for examining overt attention allocation to the distractor images, the images will need to be fixated, which, as mentioned above, was not required by the paradigm we used.

By using threat stimuli images as the search task targets, this issue will be resolved, and it will be ensured that participants will fixate the threat stimuli. Such a target search design was used in the search task of the second experiment of Chapter 3, but again no significant difference was found between the threat information and the control animal images in terms of the overt attention allocation measures. Despite the significant faster RTs to detect the threat information targets, the first fixation times were not

significantly faster on the threat information targets than the no information targets. The most plausible explanation for this unexpected finding seems to be the specifications of the search task scenes, in which the threat and control images were hidden. Finding the targets was easy in some trials, but in some other trials, finding the targets was difficult such that in many cases, the participating children found the target after repeatedly fixating the target interest area. As discussed before, this might have weakened the association between the first fixation time and RT indices, and resulted in the significant RT effect and the non-significant fast fixation effect.

In sum, attentional bias towards newly feared animal was indicated by RT effects (either delayed or facilitated RTs) in both experiments, and little evidence was found to indicate differences between overt attention deployment to the threat and control stimuli. Using easily recognisable targets in target search tasks, or other variants of visual search task such as the deviant search task, might be a better option for gauging the direct visual attention allocation responses to the threat stimuli images.

5.2. Enhancing fear and attentional bias of fear-relevant stimuli

5.2.1. Enhancing fear of fear-relevant stimuli

In the two experiments of Chapter 4, threat information was given about a snake species with the aim of inducing (or enhancing the pre-existing) fear of, and attentional bias towards, snakes. The change in the fear due to receiving the threat information was not measured in the first experiment of the chapter, because it was assumed that the effect of threat information would be reflected in the attentional responses to the threat information snake images in the search tasks. No significant attentional bias effect, however, was found in this experiment. It was, therefore, not clear whether the threat information did not increase the fear of the threat information snake, or the fear was acquired, but did not show in the search task findings. In the second experiment of this chapter, the increase of fear was measured directly using a questionnaire similar to the FBQ. The results showed that fear beliefs about one of the snake species significantly increased after receiving threat information as compared to the baseline fear beliefs. This increase in fear beliefs led to significant higher fear beliefs of the threat

information compared to the no information fear-relevant stimuli in the post-test measurements. These results suggest that self-reported fear of the snake was increased by the threat information.

In this experiment, fear was measured only by self-reported fear beliefs. Such assessment is not an optimal fear evaluation, and is prone to demand characteristics, that is, it does not rule out the probability that the participants might pretend having higher fear beliefs about the threat information snake after receiving the information. A thorough evaluation of fear should also include physiological indices, such as heart rate and skin conductance, and behavioural avoidance measures as well. The past research has shown that these fear indices (i.e., behavioural avoidance and physiological fear signs) also follow the acquisition of fear through informational learning pathway (e.g., Field & Lawson, 2003; Field & Schorah, 2007). For instance, in Field and Schorah's (2007) study, children's heart rates were significantly higher when approaching the box that they believed to contain the animal about which they received threat information compared to the box associated with the control animal. Nonetheless, because the main focus of this research was on the effect of threat information on visual attention deployment patterns, it was sufficient (as a manipulation check) to assess fear acquisition only by self-reported fear beliefs.

5.2.2. Enhancing attentional bias toward fear-relevant stimuli

In the two experiments of Chapter 4, attentional biases toward the images of the threat information and no information snakes was examined in three tasks. The tasks were designed to examine two main attentional bias effects, the threat stimuli interference effect, and the threat detection effect. Little evidence was found to indicate the enhancement of attentional bias towards the snake about which threat information was given compared to the no information snake. In the first experiment of Chapter 4, neither the threat information, nor the no information snake images, interfered with detecting an irrelevant target. In the second experiment, although the results indicated more efficient detection of the snake targets (both threat information and no information snake targets) than the control targets; no enhanced attentional bias was found towards the threat information relative to the no information snake targets. There are three explanations that will be explored: (1) threat information does not create a fear in the first place; (2) threat information changes fears but these induced fears do not create an

attentional bias; (3) threat information changes fears and does create an attentional bias, but the bias effect is weak and the measures of attentional bias are insensitive to it.

The first possibility is that the fear of the snake was not increased after receiving the threat information in the first place, and the increases in self-reported fear beliefs were not real and merely reflected the participants' conformity with the demand characteristics of the task. If this is the case, not acquiring fear can partly be due to the participants' low baseline fear of snakes. For these experiments, people with low snake phobia scores were selected to avoid a ceiling level of attentional bias to snake stimuli which would mean that the threat information could not have an effect. It is possible that these participants were more resilient to fear induction because of their low natural level of snake fear, and for this reason, they might not have acquired fear of the snake through informational learning.

The interpretation that the participants did not acquire fear after listening to the threat information would be inconsistent with several other studies by Field and his colleagues which have shown that fear can be acquired by receiving threat information. One of the main differences between the present studies and Field et al.'s research is the age range of the research samples. It might be the case that children acquire fear by receiving information more readily than adults, and induction of fear through this method in adults is more difficult. Learning history increases with age, and a longer learning history means that a more complicated process would be involved in fear acquisition. Adults might also be less suggestible than children, thus, it might be less probable that they believe the information they receive through a rather simple intervention of information giving. For these reasons, it might be more likely that children acquire fear through such a straight forward induction method, while a more sophisticated fear induction method for adults, which is adapted to account for their past learning history, might be required. To conclude more confidently that receiving threat information leads to enhancing fear in adults, examining the change in fear responses by measuring other response systems (i.e., physiological and behavioural) can be helpful.

Considering the previous research findings which show that fear is acquired by receiving threat information, and considering the participants' self-reported fears, it is also likely that fear was enhanced after receiving threat information, but this increase did not lead to an enhancement in attentional bias. The second possibility, therefore, is that the enhancement of fear does not always lead to the enhancement of the relevant attentional bias effect. It might not always be true that fear enhancement results in

enhancing attentional bias effects, and there may be some cases that magnified bias effects do not follow the increase in perceived fear. This possibility needs to be further investigated. First, it needs to be ensured that fear of fear-relevant animals has indeed increased after receiving threat information (using the aforementioned methods). Second, it needs to be ensured that no attentional bias is induced after fear acquisition by using different attentional bias paradigms, and other variants of the visual search tasks (see below). If such an enhanced bias effect is not found, then it can be concluded that increasing fear of a stimulus does not always lead to an enhancement in attentional bias towards the stimulus.

The third possibility is that enhancing fear has caused an increase in the bias effect, but the change was not detected by the attentional bias paradigms used in these experiments. This can be because the possible bias caused by threat information was not significant at a measurable level, and the paradigms used in Chapter 4 experiments were not sensitive enough to gauge the enhanced bias effect. Employing different variants of the visual search task or even different attentional bias paradigms can be helpful to examine the possible bias effect, and to ensure that all possible measures for detecting the effect have been taken. For instance, the prioritised attention allocation to threat information fear-relevant stimuli, relative to the no information fear-relevant stimuli, can be investigated in a task in which the two types of stimuli are presented in the stimulus array of the same trial. In such a stimulus array the two types of stimuli would compete to capture visual attention, and such search task designs can be effective in examining whether the threat information stimuli have any superiority over the no information stimuli in capturing attention when they are exposed simultaneously. Devising new designs of the visual search task will be needed to create such stimuli competition situations.

Other variants of the visual search task can also be employed to measure the possible bias effect caused by threat information. One of the important search task variants which was not used in the experiments of Chapter 4 is a search task that requires searching actively in naturalistic scenes. For instance, search tasks in which the threat information and no information snakes' images are concealed in naturalistic scenes as the targets that need to be detected, or as the distractors that are irrelevant to the search task instruction, but pop up to capture the participants' attention. These tasks can be considered as alternative search tasks in measuring the probable enhanced attentional bias. Such visual search strategies are closer to the way people search for, or

encounter, fear-relevant animals in real life, and such search tasks can be considered to have more ecological validity than searching the animals in matrices.

As seen in the experiments of Chapter 3 on child participants, a threat related bias effect, that is, faster RTs when detecting the newly feared stimuli relative to control stimuli, was found using such a target search task in which threat and control targets were hidden in naturalistic jungle scenes. No overt attentional bias effect, however, was found in the results of this experiment. As discussed before, one of the possible explanations for not finding the potential overt attentional biases in this experiment was the difficulty of finding the hidden targets in the jungle scenes. In the future research, therefore, manipulating the degree of difficulty of recognizing the concealed threat stimuli, and factoring in this effect in the analyses of the attentional responses data can possibly resolve this issue. By employing this method, it can be assured that the possible overt attentional responses shown to some threat stimuli with a specific degree of difficulty is not affected by the weak responses shown to the other threat stimuli with different degrees of difficulty. This type of search task can also be a useful paradigm in gauging the enhanced bias effect toward fear-relevant stimuli. Assessing the patterns of attention deployment to the snake stimuli before and after fear induction is the other method that can increase the possibility of gauging the effect of information on attention allocation patterns.

5.2.3. Specifications of the patterns of attention deployment to fear-relevant stimuli

In the experiments of Chapter 4, in addition to investigating the increase in attentional bias toward snake stimuli due to receiving threat information, the general fear-relevant bias effects were also examined. This baseline attentional bias towards fear-relevant stimuli was measured by comparing the attentional responses to the snake species in general with the control fear-irrelevant stimuli. As mentioned above, two bias effects of interference and threat detection were investigated in the two experiments.

With regard to the interference effect of threat stimuli, the first experiment examined whether the presence of a single image of a snake in the stimulus array distracts participants of their task to respond to an irrelevant target. This effect was not found: neither the participants' RTs to detect the target, nor their first fixation times on the target, were delayed by the snakes' image. The snake distractors also did not attract

any more saccades before fixating the targets than did the fear-irrelevant control distractors. Thus, a single fear-relevant distractor image did not interfere with detecting an irrelevant target. These findings are inconsistent with the previous research (e.g., Miltner, et al., 2004), which showed that a single distractor image of the participants' feared animal is enough for distracting phobic and fearful participants and interfering with their responses to the task. Again, it is possible that the experiments' sample, which consisted of low snake phobia scorers, has contributed to the non-significant results. It can be assumed that single spider image for spider phobics (e.g., Miltner, et al., 2004) is more distracting than a single snake image for low snake phobia scorers. The effect of threat information, however, could have increased the interference effect of the snake images, and have resulted in delays in detecting the targets. Although it is not expected that listening to threat information in one session turns the participants with low snake phobia scores to snake phobics, based on the findings of the first experiment of Chapter 3 in which single newly feared animal images interfered with children's responses in a task with a similar design, such a distraction effect by snake images after receiving threat information was expected. As discussed before, not finding such an effect in adults might be partly due to the developmental differences between the child and adult samples in terms of children's shorter learning history, and in their higher suggestibility.

To maximise the possibility of gauging a probable distraction effect caused by the snake stimuli, the distractor images in the second experiment were presented in an odd-one-out search task. In this task, mass presentation of snake images not only did not delay the detection of deviant (fear-irrelevant) images, it even speeded the detections. Thus it seems that not finding the distraction effect was not due to the search tasks designs, but due to the participants' specific attentional allocation responses to the snake images. In the odd-one-out search task, the snake distractor images were dwelt on less than the control distractor images, which might imply on a possible avoidance of the snake images. This effect was associated with significant faster RTs when detecting the fear-irrelevant targets amongst snake distractors than amongst the control distractors. If the participants were avoiding the snake images, it might have been the reason of the faster detection of deviant targets in the trials with snake distractors. Based on this argument, it is possible that avoiding the snake images in these trials, which were presented in all the matrix grid locations except the deviant image, and trying to terminate the search on the snake images led to fixating faster on the deviant image.

In the odd-one-out search task, RTs were faster to detect the snake targets than the control targets. Interestingly, however, the control targets (fish images) were fixated faster than the snake targets. This interaction effect would rule out the possibility that faster detection of snake images was due to the higher distinction of the snake images from the background images as compared to the distinction of control targets from the background images. Thus it might be reasonable to suggest that the origin of fear-relevant attentional bias found in this task might be the more efficient processing of threat related images rather than faster automatic gaze directions on the images.

Similar to the deviant search task, in the target search task of this experiment, snake target images were detected faster than the fear-irrelevant control targets, but in the target search task the effect was indexed by both faster RTs and faster first fixation times. Providing that dwelling less on snake images in the odd-one-out search task was due to avoiding the images, with the faster detection of snake images found in both tasks, there might be a pattern of vigilance-avoidance when attending to snake stimuli in the results of this experiment. There were also some signs of such pattern in the results of the first experiment of this chapter which lend some support to this notion. Although the results of the first experiment of this chapter were mixed and in many cases non-significant, the pattern of mean differences generally showed that threat related stimuli were fixated faster and dwelt for shorter times than the control stimuli. If the interpretation of the existence of hypervigilance-avoidance pattern is correct, and if the participants did not acquire enhanced fear of snakes due to receiving threat information, the hypervigilant-avoidant pattern when attending to fear-relevant animals' images might be a general effect that exists even in non-fearful participants.

In the target detection task and the target detection condition of the deviant search task, significantly longer first fixation durations on snake target images than the control target images were found. This finding is consistent with a freezing response when encountering threat stimuli (Fox, et al., 2001). An opposite effect, however, was found in the first experiment, in which the distraction effect of a single snake image in the stimulus array was examined. In this task, the duration of the first fixation on snake distractor images was significantly shorter than this duration on amphibian filler images. These contradictory results might have originated from the differences between the threat stimuli's positions in their relevant stimulus arrays, as in the first experiment, the snake images were distractors (i.e., detecting them was not instructed), and in the two detection tasks they were targets. This might have played a role in the differences

between the results: it might be the case that longer first fixation durations effect (the possible freezing response) occurs only when people search specifically for the threat stimulus in the surroundings.

In sum, firstly, the threat information did not enhance attentional bias towards a type of snake species. Secondly, the participants were not distracted by single snake images in the array. If it is true that the threat information did not have the expected effect on enhancing fear of the fear-relevant stimuli, not finding the distraction effect might be because of the participants' low actual fear of snakes and their low snake phobia scores. The effect of a single snake image might not have been strong enough to distract these participants from detecting the fear-irrelevant targets. In other words, these participants were not as vigilant as spider phobics were shown to be towards spider images (e.g., Miltner, et al., 2004). Finally, the participants showed attentional bias towards snake images, when they were instructed to find the snake image as a target or a deviant stimulus, and might even have displayed signs of vigilance-avoidance, when the distractors were presented massively in the arrays.

5.3. Comparison of naturally occurring and induced threat related attentional biases

Two main naturally occurring (or pre-established) threat related attentional bias effects were investigated in child and adult samples in this thesis. The first bias effect was the bias toward angry facial expressions in children, and the second effect was the bias towards fear-relevant stimuli in adults (i.e., snakes).

Schematic line drawing faces were used in the first study in an eye-tracked visual search task to specify the overt threat related attention deployment patterns in children, which were considered as the baseline patterns in this age range. Similar to the original study (i.e., Hadwin, et al., 2003), children's RTs were faster when detecting angry facial targets than happy and neutral targets, which indicates an efficient threat detection effect. Such efficient threat detection was also found in the first fixation times on targets, but in these results, the happy facial targets were also fixated faster than the neutral targets. Moreover, the first fixations lasted longer on angry face targets than the neutral targets, but the difference between angry and happy faces was not significant. The pattern of the means of the other eye movement indices was consistent with the

threat attentional prioritisation predictions (e.g., longer dwell times and higher fixation counts on angry facial expressions than the other expressions), however, many of the mean differences were not significant and the significant findings were not entirely consistent with the predictions. In sum, the RT effects specifically, and the eye movement results in general, supported the threat related attentional biases in this experiment.

The attentional prioritisation of threat related targets was also found for fear-relevant animals in RT and eye movement measures in both the target and odd-one-out search tasks of Chapter 4 (as mentioned in the previous section). The similarities between the two types of pre-established threat related biases (i.e., towards angry facial expression and fear-relevant animals) is that both types of threat targets were detected faster than the neutral targets, and the first fixations lasted significantly longer on the threat targets than the neutral targets. In the results of both types of pre-established biases, it seems that RT results were more consistent than the first fixation time results with the predictions of threat prioritisation account. The difference between the attentional responses to the two types of threat related targets was mainly the tendency of dwelling on the stimuli. While there was a tendency to dwell more on angry facial expressions than the neutral expressions (shown by some attention dwelling indices), the fear-relevant targets were dwelt on less than the control targets. It was found that after a long first fixation on the fear-relevant targets (which might indicate a freezing response), in the rest of the search, the images were fixated less than the fear-irrelevant targets (it might be the case that fear-relevant images were avoided). In the case of threatening facial expressions, the first fixation similarly lasted longer on these target faces than the neutral expressions, but the tendency to dwell more on the threat stimuli continued in the rest of the search time.

The acquired attentional bias was examined in a target search task, that is, the task in which the targets were hidden in jungle images, and the results indicated that the participating children's RTs were faster when detecting the threat targets than the control targets. This effect was the only significant attentional bias effect found in this study, and none of the eye movement indices results indicated a threat related bias effect. Part of this lack of eye movement effects can possibly be explained by the difficulty of detecting the targets in this task. Not all of the unexpected eye movement results, however, are explicable in terms of the search task's specifications. For instance, even with the hidden threat targets, it would be expected based on the threat

attentional prioritisation account that the first fixations last longer on these targets than the control targets after the targets are detected. This effect was not found. The participating children, contrary to the responses to the naturally occurring bias stimuli, also did not show any avoidance of, or prolonged dwelling on, the threat targets. Therefore, it might be reasonable to suggest that attentional responses to pre-established threat stimuli might be different from the responses to newly acquired fear stimuli. It is worth mentioning that the conclusions in this section are made by comparing studies in which different methods, samples, and stimuli were used. Therefore, these general conclusions are only proposed as probabilities that need further investigation, and are nowhere near certain conclusions.

Although the results support the notion that human's cognitive system is responsive to new threat input, and the RTs to newly defined threat stimuli is faster than the RTs to neutral stimuli; the results might also imply that the attentional responses to the newly defined threat stimuli are not identical to the responses to long established threat stimuli. It might be reasonable to suggest that overt attentional responses such as freezing and avoidance might be specific to long-established threat stimuli, whereas the stimuli whose fear has been learned recently in a short learning episode through an indirect fear pathway do not elicit such responses. Repetitive exposure to such fear learning experiences might lead to attentional biases similar to the naturally occurring biases. To examine whether the extended fear induction sessions can elicit full-blown threat related attentional bias responses, it will be helpful to compare the bias effects that are acquired in a single fear induction session to the effects that are acquired in extended induction sessions in the future research. Moreover, as discussed before, attentional biases toward newly acquired feared stimuli was not examined in the experiments of the current thesis by using easily recognisable images of the stimuli in target search tasks. Conducting such search tasks can also yield more information about the visual scanpaths patterns related to the induced attentional bias stimuli, and can ensure us about the accuracy of the conclusions made in this discussion regarding the bias effects.

In addition to examining the efficient detection of both newly learned and pre-established threat targets, in the studies of this thesis the interference effect of both types of threat stimuli were also examined. In the first experiment of Chapter 3, the interference effect of newly feared animals was found, according to which single images of the animals distracted the participating children when searching for a fear-

irrelevant target in the stimulus arrays. Such an interference effect, however, was not found for fear-relevant animals' images when single images of the animals were used as the distractor images in a search task with a similar design. Moreover, such an effect was not found even when the fear-relevant animal images were presented massively in the stimulus arrays as distractors. It can be suggested confidently that not finding the interference effect of fear-relevant images does not result from the designs of the search tasks: the effect was found for the newly feared animal's stimuli in the previous search task in which a single threat animal images was used as the distractor (for children), and massive presentation of fear-relevant animals' images has been shown to be effective in eliciting the interference effect in previous studies (e.g., Rinck, et al., 2005). A possible explanation for these results can be that the interference effect of a threat stimulus might be specific to the people who have actual fear of the stimulus. As mentioned before, there is a possibility that fear of snakes was not enhanced in adults by threat information, and the elevated self-reported fear beliefs were expressed due to a demand characteristic. If this was the case, there might be the possibility that the newly feared animals were actual fear stimuli for children, but the snakes for the adults were not so, therefore the two types of threat stimuli did not cause similar effects.

Comparing the direct attentional deployment responses across both types of tasks (search tasks with interference designs and search tasks with target detection design) also imply that the pattern of the responses to the newly feared and fear-relevant animals' images seemed to remain rather stable across both types of search tasks. In both types of search tasks little evidence was found for differential overt attention allocation to the newly feared and the control novel animals, and in both types of search tasks, the gaze dwelling indices often indicated attenuated dwelling on fear-relevant as compared to fear-irrelevant animals, which might possibly imply on avoiding the fear-relevant animal stimuli. Such attenuation in dwelling on threat stimuli was not found for the newly feared animals. These findings again could support the notion that the overt attention deployment responses might be specific to long-established threat stimuli and might not appear for the threat stimuli soon after fear of the stimuli have been acquired.

In sum, by comparing the naturally occurring and newly induced biases, the possible general conclusions that can be made are that efficient threat detection occurred for both newly feared and fear-relevant stimuli, interference effect might have been caused by the stimuli of which people have actual fear, and overt attention allocation responses might have been demonstrated to pre-established threat stimuli, but

not to newly acquired fear stimuli. It is worth mentioning again that the general conclusions in this section are drawn by comparing the results of diverse experiments of this thesis which have used different search tasks, samples, and stimuli. Such notable methodological differences limit the comparability of the results, and affect the level of certainty of the conclusions drawn from the comparisons. Thus, we need to keep in mind that the inferences made based on the general comparisons in this section are by no means certain: they are proposed only as possible explanations and further research will be needed to verify them.

If we ignore these limitations affecting the comparability of the different studies' results, and assume that the general conclusions are correct, it can be suggested that attentional bias responses have different levels that are formed over time. The efficient processing of newly feared stimuli might be amongst the first line of responses that are formed; therefore, they are displayed by children who have just learned to fear a stimulus. The overt attention deployment effects, such as freezing response or vigilance-avoidance response pattern, however, might be formed over time and might not be shown to newly acquired fear stimuli. On the other hand, the interference effect was found for newly feared novel animals but not for threat information fear-relevant animals. There is a possibility that fear of fear-relevant was not enhanced by threat information. If this was the case, it might be possible that the interference effect occurs only for the threat stimuli of which people have actual fear, but not to the fear-relevant stimuli for the people who have low fear of them. Further research is needed to reach a conclusive stance as to whether threat information will indeed enhance fear of fear-relevant animals in adults. Nevertheless, even if the participating adults with low snake phobia scores did not acquire fear of snakes through threat information, they displayed efficient target detection and overt attention allocation responses to all snake stimuli (not only the threat information snakes). These findings further support the proposals that subtle cognitive fear templates are involved in responding to fear-relevant stimuli, and this might be the reason that they are processed efficiently, and elicit overt attention deployment biases.

5.4. The relationships of threat related attentional biases and anxiety and phobia scores

In the first study of this thesis, a significant effect of the participating children's trait anxiety scores on their RTs to decide whether an angry face target was present among control facial stimuli was found. The participants with higher trait anxiety had faster RTs when deciding whether an angry face was present or absent in the stimulus arrays comparing with their RTs to decide about the presence or absence of happy and neutral faces. This finding is consistent with the past child anxiety models (e.g., Lonigan, Vasey, Phillips, & Hazen, 2004) which predict that children with elevated anxiety demonstrate magnified threat related attentional bias. As discussed in Chapter 2, this effect of anxiety on the participants' RTs also implies that the overt attentional prioritisation of the angry facial expression in this experiment was not merely due to the angry face stimuli features distinctions, and might be indeed because of the emotion that is expressed by the facial stimuli. In this experiment, this was the only attentional bias index which had a significant relationship with the participants' anxiety levels, and such an effect was not found for any of the eye movement indices; therefore, the findings were not fully supportive of the threat prioritisation account's predictions.

In the two experiments of Chapter 4, participants' trait anxiety and snake phobia were also tested, but a noteworthy relationship was never found between the attentional biases towards snakes images and the participants' scores of trait anxiety and snake phobia. It is expected that the individuals higher in the predisposition factor of trait anxiety are more prone to react fearfully to threat stimuli (e.g., Muris, 2007). Part of these fear reactions can be attentional bias towards threat stimuli; therefore, anxious individuals are predicted to be more prone to acquire fear-relevant attentional biases. Moreover, there are two models that predict the change in attentional responses as the levels of threat in the stimuli increase. The biased attentional direction theory (Williams, et al., 1988, 1997), predicts that as the threat level increases, highly anxious individuals increasingly attend to the stimuli, and low anxious individuals increasingly avoid them. The shifted attentional function theory (or the cognitive motivational theory, Mogg & Bradley, 1998; Mogg, McNamara, et al., 2000) on the other hand, predicts that both high and low anxious individuals become more vigilant, and show higher attentional bias, as the threat level of the stimuli increases. In the present

experiment, the no information snake can be considered as the stimuli with low threat level, and the threat information snake as the stimuli with high threat level. Thus attentional bias towards these stimuli can be predicted to interact with participants' anxiety scores. None of these relationships between trait anxiety and attentional responses to threat stimuli were found in the present experiments. It is also expected that the individuals with higher snake phobia scores show higher attentional bias effects, but it was not found in the experiments in Chapter 4. This can be due to the participants' generally low phobia scores that limited the range of snake phobia scores' variance. If there were highly snake phobics in the sample, it might have been possible to find magnified attentional bias effects.

5.5. Theoretical Implications

The experiments of Chapter 3, consistent with the previous studies by Field and his colleagues (Field, et al., 2009; Field, 2006c, 2006a), showed that induction of fear of novel stimuli leads to acquiring attentional bias toward the stimuli. Such findings imply that acquiring attentional bias towards novel stimuli is a result of the acquisition of fear of the stimuli. On the other hand, the research by McLeod and his colleagues (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002) has shown that inducing attentional bias can increase state anxiety in people, which suggests that attentional biases cause anxiety. It might be reasonable to consider the relation between the states of fear and anxiety and threat related attentional biases as a bi-directional association. Whilst being in a state of anxiety and fear will make the anxious/fearful people vigilant for threat cues and facilitates directing their attention to the danger signalling stimuli, at the same time causing a non-anxious person to be vigilant for threats in the surroundings and to excessively attend to dangerous stimuli can affect their mood state and elevate their anxiety levels.

The current research also found evidence of attentional bias toward fear-relevant stimuli. This evidence provides further support for Öhman and Mineka's (2001) model that humans are neurologically hardwired to perceive poisonous animals as threat sources. On the other hand, threat information did not enhance the bias effect towards the fear-relevant stimuli. There were two main differences between the experiments in which enhancement of attentional bias towards fear-relevant animals was investigated,

and the experiments of Chapter 3, in which attentional bias towards novel stimuli were increased after receiving threat information. These differences were the age range of the samples (children versus adults) and the stimuli (novel versus fear-relevant). Not finding the enhanced bias effect might, among other implications, imply that fears that are acquired through receiving threat information are reflected more readily in the attentional responses of children comparing with the ones of adults. In other words, the cognitive system of children is more responsive in the recognition and prioritisation of newly acquired threats relative to the ones of adults. The other possibility is that measuring the enhancement of the bias towards fear-relevant stimuli, relative to novel stimuli, is more difficult and needs a more dramatic increase because of the baseline bias that exists for the fear-relevant stimuli. Clarifying both possibilities will need further investigations.

In all of the experiments of this thesis RT effects were found to be more stable and more consistent with the threat prioritisation account's predictions than eye movement effects. This pattern of findings might imply that the source of threat related attentional biases, and the reason of magnified bias effect in anxious individuals, might be more efficient recognition and processing of threat stimuli after the threat sources are initially fixated. Although in most cases of the present research the threat related stimuli were also fixated faster than the control stimuli, in some cases the threat stimuli were not fixated any quicker than the control stimuli, and in some cases the control stimuli were even fixated faster than the threat stimuli, but RTs to detect the threat stimuli were faster than the RTs to detect the control stimuli. It might, therefore, be reasonable to argue that efficient processing of threat stimuli, not merely the automatic eye movement responses, is the more probable basis of threat related attentional biases, and that the higher order cognitive functions are more involved than the reflexive eye gaze directions in threat prioritisation effects.

5.6. Clinical Implications

It was discussed in the previous section that attentional bias effects might have different levels that develop over time: while efficient processing might be formed soon after fear of a stimulus is learned, overt threat related attentional responses, such as freezing effect or hypervigilance-avoidance pattern, might appear only after fear of a stimulus is intensified (although, as mentioned before, these conclusions are explanation

proposals that need to be verified by further investigations). In theory, fear intensification and phobia development can occur by receiving threat information, if the informational learning episodes are repeated for a significant number of times. It can be predicted that such a process will lead to full-blown attentional bias, including the threat related overt attention deployment patterns, even to novel stimuli. While further research can answer whether eye movement responses do not form at all after fear is learned through informational learning, or the responses develop through the proposed process; the probable effect that overt attentional responses were not formed soon after receiving threat information can have some clinical implications. Avoidance, as a threat related eye movement response for instance, is considered to play a role in maintenance and exacerbation of fear, because it prevents habituating with fear stimuli. Informational learning not leading to avoidance response means that fear of a novel stimulus that is learned through information would not be exacerbated because of the attentional avoidance. If developing avoidance response is gradual, it means that an early intervention can help preventing the intensification of fear before the avoidance response is formed and before the vicious circle of avoidance-fear enhancement is commenced.

The other implication of the current research results is the need to adjust the threat related attentional control training programmes based on attentional bias effects patterns. A threat related attentional bias modification programme has been developed (Dandeneau & Baldwin, 2004) based on the visual search paradigm which aims to train the inhibition of the processing of socially rejecting stimuli. In this training programme, smiling (receptive) face targets are presented amongst frowning (rejecting) faces and the participants are instructed to find the smiling face as fast as possible while ignoring the socially rejecting distractors. It has been shown (Dandeneau, et al., 2007) that the intervention indeed attenuated the threat related attentional bias effect and was shown to decrease the participants' social stress as well. The programme seems to be a suitable option for correcting social anxiety related attentional biases because its main training, that is, ignoring the threatening faces, seems to be helpful in correcting the vigilance and excessive dwelling on threatening faces. Such results can be optimal for social anxiety related attentional dysfunctions, but not for the attentional dysfunctions related to fear of animals. As discussed before, the current research, in line with the previous findings, suggests that there might be some differences between the attentional responses to threatening facial expressions and fear-relevant animals. Although in both

cases threat stimuli were detected faster, contrary to the threatening faces, fear-relevant animals' images were dwelled less than the non-feared animal images. This is similar to the avoidance effect found in spider fearfuls when they encountered their feared animal stimuli (e.g., Pflugshaupt, et al., 2005). The existence of an avoidance response to feared and fear-relevant animals' stimuli means that using a similar training programme as used by Dandeneau and his colleagues for correcting the attentional bias towards fear-relevant animals might lead to mixed results. It might attenuate the sufferers' hypervigilance dysfunction, but it would probably enhance their already high avoidance, and no need to say that increasing the avoidance response might even exacerbate their fears. An optimally tailored attentional bias modification programme for correcting attentional bias toward fear-relevant animals, therefore, would decrease both hypervigilance and avoidance dysfunctions in the fearful individuals.

5.7. Limitations and Future Research

One of the main limitations of the studies of this thesis was the inconsistency in the age range of the employed samples, and related to this issue, the lack of optimal consistency in the designs of different visual search tasks used in the studies.

As mentioned before, due to the difficulty in recruiting child participants, the last two experiments were conducted using adult samples. Developmental differences between children and adults raise concerns when comparing the results of the studies and attempting to draw general conclusions. As an instance of the developmental differences that can affect search tasks' results, the age related differences in the speed of RTs can be mentioned. It is well known, and has been repeatedly shown in different cognitive psychology tasks including search tasks paradigms, that adults have faster RTs than children (Kiselev, Epsy, & Sheffield, 2009). Moreover, older children have faster RTs than their younger counterparts (Boeren, Muris, Bouwmeester, Field, & Voerman, 2011), and therefore, the variance of RTs in children can be considered more diverse than this variance in adults. For these reasons, mixing adults and children in the same experiment sample, or making direct comparisons between adults and children in attentional bias paradigms, which rely on the speed of participants' responses, will not be methodologically sound. Conducting separate experiments on children and adults, then drawing general conclusions based on their performances in attentional bias tasks,

however, is not considered problematic, and has been done before (e.g., LoBue & DeLoache, 2008). For instance, in LoBue & DeLoache's study, children's and adults' attentional biases to snake stimuli were tested separately in similar search tasks using manual RTs, and it was concluded that children similar to adults display attentional bias to the stimuli. There is, however, a major difference between the comparisons that were made between adults and children's search tasks results in the current thesis studies and the ones of the aforementioned studies. In the previous studies, such comparisons were made based on similar search task designs and similar stimuli, but this was not the case for the current thesis studies.

In the present studies, attentional biases to different threat stimuli were investigated, and different variants of visual search tasks were employed to measure the threat related attentional biases. Firstly, in the child studies, it was attempted to induce threat related biases towards novel animals, and no initial attentional bias towards these stimuli was predicted to be displayed. In the adult studies, on the other hand, it was attempted to enhance attentional bias towards fear-relevant animals, and a baseline attentional bias toward the fear-relevant stimuli was predicted to be displayed by the participants. Such a difference in the stimuli was also associated with a change in the designs of the search tasks used in the different studies: in the child studies there were only two conditions: no information (non-feared) novel animal, and threat information (newly feared) animal; but in the adult studies, there were three conditions: fear-irrelevant control animal, no information fear-relevant animal, and threat information fear-relevant animal.

The second inconsistency in the search tasks designs pertains to the differences among the variants of visual search paradigm used in the child and adult studies. More specifically, the task involving the search for threat targets in naturalistic scenes was used in the child studies but not in the adult studies. This was because the attempts to make naturalistic search task scenes to be used in the adult studies did not lead to creating suitable images comparable with the ones used in the child studies, especially due to the differences in the tasks designs and stimuli. Moreover, the results of this search task in children, with regard to overt visual attentional responses, were not satisfactory, and this was another reason that we did not make excessive efforts to prepare the materials for a similar search task in adults. Therefore, instead of conducting the visual search in naturalistic scenes, two other variants of visual search task were used in adult studies: target search and odd-one-out search tasks. These two variants of

the visual search task were not used in the child studies. Thus, in sum, the only variant of the visual search task that was used in both child and adult studies was the target search task with interference design (in which threat stimuli are presented as distractors while the participants search for a non threat target in the stimulus array).

This lack of consistency in the search tasks employed is the main limitation for drawing general conclusions from the studies' results. The problem is that the differences among the results can be attributed to different factors: there are differences between the stimuli used (i.e., novel versus fear-relevant), between the employed samples (i.e., children versus adults), and between the variants of the visual search paradigm used (e.g., using naturalistic images versus stimuli matrices) across the studies. Each one of these factors can be the source of the difference between the studies' results. For instance, there was a remarkable difference between the patterns of attentional biases toward the newly feared animals in child studies and the pre-established threat stimuli in both child and adult studies. The difference was that no noteworthy direct attentional deployment effect was found for the newly feared stimuli (e.g., they were not fixated faster and were not dwelled for longer times than the control stimuli), but for the naturally occurring threat stimuli, that is, angry facial expressions and fear-relevant animals, such eye movement effects were found. A general possible explanation was given about this difference in the previous discussions, according to which it might be the case that the eye movement effects, such as freezing response, is specific to long-established biases and might not appear soon after the bias is acquired. This, however, is only a possibility and nowhere near a firm conclusion, because not only the stimuli were different in the studies, but also different search task variants were used to measure the biases. The biases towards novel animals were tested using a target search task aiming to measure the interference effect, and a target search in which threat stimuli were hidden in naturalistic images. It is possible that eye movement effects such as fast first fixation (which was found for the naturally occurring biases) would have been found for the newly induced attentional biases as well, if a target search task with easily recognisable targets or an odd-one-out search task (similar to the search tasks used for naturally occurring threat stimuli were found) had also been employed for testing the induced bias effects. It was not possible to conduct these useful studies for the current thesis, and they can be done in the future research.

The time considerations concerning the use of child participants was the other constraint of the experiments of Chapter 3. Considering that these studies were designed

for children as young as 6-year-old, we needed to ensure that the length of the experiments would not be problematic for the participating children. For this reason, only the necessary materials and tasks were included in the experiments, and for instance, the children's trait anxiety and animal phobia levels were not examined in these experiments. Administering these tests would have provided theoretically interesting data, because these factors (trait anxiety and animal phobia) might be predispositional factors in acquiring fear of novel stimuli. Thus, for instance, anxious children might acquire fear of, and attentional bias towards, the stimuli more readily than the non-anxious ones. To address the role of trait anxiety and fearfulness in facilitating the acquisition of fear and attentional biases through receiving threat information, it would have been useful to factor in/control for these variables' effects in the present child studies. It would have also been useful to run follow-up studies to the experiments that found evidence for attentional biases toward newly feared animals. It is possible that the bias effects found in the child studies are short-lived and will not last long after the acquisition, if the association between the stimuli and threat is not reinforced. These were not possible in the current thesis, and can be pursued in the future research. It will also be useful to examine in follow-up studies how long such threat related biases that are acquired in a single episode of informational learning will last. Moreover, in child studies, overt attentional responses to the novel threat stimuli were not found. Further fear induction sessions can be administered to examine whether they can create full-blown bias effects that include the overt threat related attentional biases. This and the other possibilities can be examined in the future research, which can yield worthwhile knowledge about the development of attentional biases.

The fifth experiment of this thesis examined whether receiving threat information leads to increasing fear and attentional bias of fear-relevant stimuli. Although it was found that self-reported fear of the fear-relevant stimuli had been increased after receiving threat information, this did not lead to enhancing the attentional bias effects. Administering a more thorough fear assessment by evaluating other fear signs (such as skin conductance) can be helpful in ensuring whether fear of the fear-relevant animal has been indeed enhanced or not. Moreover, including the implicit associations test in the assessment, to examine whether the threat stimuli have become implicitly associated with threat more than the control stimuli, will also be helpful in such an assessment. It might also be useful to conduct visual search tasks before and after fear induction, to

examine more precisely the possible changes in the attentional responses to the stimuli due to receiving threat information.

A general limitation of the prospective studies of fear learning is ethical considerations. Theoretically, it is possible to acquire full-blown phobias by receiving threat information when the process of information giving is repeated in an extended period of time. For ethical reasons, however, causing excessive distress in participants until a full-blown phobia is induced will not be acceptable. Therefore, a solution is needed for future research to address the question of whether threat information can indeed lead to developing severe fears and phobias, or a direct conditioning episode is necessary for creating such fears. Devising a research scenario in which informational learning episodes are repeated in an extended period of time and through various media without breaching appropriate ethical considerations can provide the opportunity to investigate the possibility of learning more severe fears and acquiring the concomitant attentional bias effects through the information pathway. Conducting such research and comparing its results with the ones of the single fear induction sessions can be helpful in understanding the process of threat related attentional biases formation, and can show us whether full-blown threat related attentional biases can be acquired through informational learning.

There are also differences between fear learning and reacting to feared stimuli in the real world and in the experimental settings. Methodological and ethical considerations limit the possibilities of making the two settings as similar as possible. For instance, the ways of receiving threat information and encountering threat stimuli are different in these two situations. In the real world, we receive threat information from different sources, such as teachers, books, magazines and mass media. For example, many of us now know that king cobra snakes, and black widow spiders are lethal species. We usually receive such information from the media, and integrate the information in the way we act in the situations where we may encounter the actual animals. This process is different from the process of receiving information through earphones and searching in stimulus arrays on computer screens. It is reasonable to assume that in situations closer to the real world experiences, participants' responses would be different from their responses in the controlled experimental settings. As discussed in Chapter 1, it has already been shown that attentional responses to feared animals in virtual interactive search tasks is different from the responses to the stimuli which are presented as images on screens: while spider phobics avoid spider images

displayed on screens after a quick initial fixation on the images (e.g., Rinck & Becker, 2006), in the virtual interactive search task, they keep spider images within their sight (Rinck, et al., 2010). Ideally, it is better that the experimental settings are as similar as possible to the real world experiences. This however, may not always be practical. For example, it does not seem practical, and even ethically acceptable, to broadcast false threat information via mass media for the purpose of conducting research on fear learning processes. Instead, more sophisticated research designs will be needed to research the processes. As an example in this context, a practical scenario can be providing false threat information about an unfamiliar species to the people who are going on an expedition tour by the tour guides and information booklets and so on. To investigate the effect of the information, the tourists' behavioural responses to the real species when they are on the tour, and their visual attentional responses to the species' stimuli (e.g., measured by modern portable eye-tracking equipments), can be examined. Such ways of giving information and assessing the behavioural and attentional responses can be considered as more effective and ecologically valid than the methods used in the current experiments. Conducting such research will be helpful in disentangling the fear learning processes, and in investigating the way we assimilate the new knowledge about threats, and react to the threat stimuli accordingly.

5.8. Final Summary

In the first experiment, threatening facial expressions were detected faster, dwelled for longer times, and the first fixations on them lasted longer relative to other facial expressions. The participants' trait anxiety had significant relationship only with RTs to decide about the presence of the threatening facial expressions amongst control stimuli. In the second experiment, the images of a novel animal about which threat information was given delayed the detection of a fear-irrelevant target amongst other novel animal images, and in the third experiment, the RTs were faster to detect the threat information than the no information novel animals' images which were hidden in naturalistic scenes. In the second and third experiments, little evidence was found for differential direct attention deployment to the threat information and no information novel animals' stimuli. In the fourth and fifth experiments, there was no significant difference in terms of attentional bias effects between the fear-relevant animal about which threat

information was given and the fear-relevant animal about which no information was given. In the fifth experiment, faster RTs to detect fear-relevant animal images, relative to control animal images, were found in both target and odd-one-out search tasks. Faster fixation on the fear-relevant animals' images, however, was found only in the target, but not the odd-one-out search task. It was concluded that the faster detection of the fear-relevant stimuli might not be due to the automatic gaze orientation, but because of more efficient processing of the stimuli. The first fixations also lasted longer on the fear-relevant animal images than the control animal images in both search tasks. After the fast detection of fear-relevant targets, and long first fixations on them, which indicated a vigilance attentional response; dwelling on the fear-relevant targets attenuated in the remaining time of the search. It was concluded that there might be signs of a vigilant-avoidant pattern of attention to snake stimuli in the participants of this experiment, who had been screened for the experiment based on their low snake phobia scores. Some general conclusions were also made by comparing the patterns of the naturally occurring and newly induced threat related attentional biases found in child and adult studies. Although these conclusions are not definite and need to be verified in the future research, the results of this thesis' studies might imply that RT is a more stable index of threat related attentional biases; and that the effect of fast detection of threat stimuli might appear soon after fear of a stimulus is learned, but overt attentional bias effects such as freezing effect or vigilant-avoidant response pattern might form over time and occur only for the deeply settled fears.

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Appendices - Appendix A: Parental consent forms

The first child study's (Experiment 1) parental consent form

Dear Parents,

We invite your child to take part in some research which will examine children's visual attention patterns, and is part of a doctorate in psychology research thesis.

Participating children will complete a questionnaire asking about their emotional status. This questionnaire is commonly used and has been designed for children of this age. Then, they will do a brief computer-based task in which, they will be asked to look for line drawings of human faces expressing an emotion (anger, happiness or neutral) amongst some faces that are not showing that emotion. During this task, children's eye movements will be recorded using a small camera in front of the computer screen that is specially designed to record eye movements.

As a participant, your child will be under no stress, risk or discomfort. Based on considerable past experience, we anticipate that your child will find the session an enjoyable experience.

Participation is entirely voluntary. Children are free to withdraw from the study at any time without explanation.

Individual names will not be recorded, and the collected data will be kept completely confidential. No conclusions will be drawn about any child's ability or school performance.

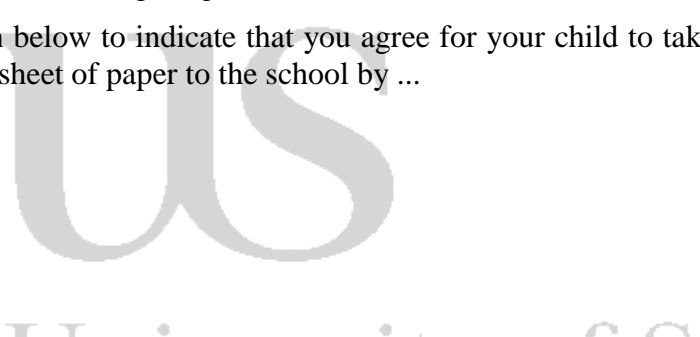
The study has been reviewed by the ethics committee of the School of Life Sciences, University of Sussex. If you have any questions about the study, please contact the supervisor of the study, Dr. Andy Field, at the University of Sussex: Tel. 01273-877150 or by email at andyf@sussex.ac.uk; or the researcher, Saeid Rohani, at the University of Sussex: Tel. 01273-877492 or by email at s.rohani@sussex.ac.uk.

If you are happy for your child to participate then please explain to your child that if at any point they do not wish to continue with the experiment, they should tell the experimenter and they can stop.

If you have:

- Read the information above and understood it
- Asked questions if you wanted to, and got satisfactory answers
- Understood that your child is free to withdraw from the experiment at any time without explanation
- Explained to your child that they are free to withdraw from the study at any time, without giving a reason

Please sign below to indicate that you agree for your child to take part in the study and return this sheet of paper to the school by ...



Name of child (in block letters): _____
 Name of Parent (in block letters): _____
 Parent's signature: _____ DATE: _____

The second and third child studies' (Experiments 2 and 3) parental consent form

Dear Parents,

We invite your child to take part in a research on visual attention, which is part of a doctorate psychology research thesis, and will examine how information affects children visual attention.

Participating children will do a brief computer-based task in which, first, they will be shown some pictures of 2 Australian animals and will be asked some non-invasive questions about each (such as 'Do you think this animal looks scary?'). They will then be told some information about the animals before answering the same set of questions about them.

Finally, they will be asked to search for the image of one of the animals in a picture displayed on a computer screen, and their eye movement will be recorded while they are searching. The task is similar to an interactive exhibit in a museum (i.e. the science museum), and is all done by a laptop computer and an eye movement recorder, that is a small camera which will be put in front of the computer screen.

For the research purposes, the information which will be presented about the animals in the computer-based task will not be always true, and some of the information will be unreal. Nevertheless, as soon as we finish running the research, we will have a debriefing session in which participating children will learn the factual information about the animals' lives by playing some interesting games. (Please do not talk about the contents of this letter to your child before the debriefing session, because doing so will affect results of this research.)

As a participant, your child will be under no stress, risk or discomfort from taking part in this research. We anticipate that your child will find the session an enjoyable experience, as children participating in past experiments using similar procedures have enjoyed the experience.

Participation is entirely voluntary. Children are free to withdraw from the study at any time without explanation.

Individual names will not be recorded, and the collected data will be kept completely confidential. No conclusions will be drawn about any child's ability or school performance.

The study has been reviewed by the ethics committee of the School of Life Sciences, University of Sussex. If you have any questions about the study, please contact the supervisor of the study, Dr. Andy Field, at the University of Sussex: Tel. 01273-877150 or by email at andyf@sussex.ac.uk; or the researcher, Saeid Rohani, at the University of Sussex: Tel. 01273-877106 or by email at s.rohani@sussex.ac.uk.

If you are happy for your child to participate then please explain to your child that if at any point they do not wish to continue with the experiment, they should tell the experimenter and they can stop.

If you have:

- Read the information above and understood it
- Asked questions if you wanted to, and got satisfactory answers
- Understood that your child is free to withdraw from the experiment at any time without explanation.
- Explained to your child that they are free to withdraw from the study at any time, without giving a reason

Please sign below to indicate that you agree for your child to take part in the study and return this sheet of paper to the school by...

Name of child (in block letters): _____

Name of Parent (in block letters): _____

Parent's signature: _____ DATE: _____

University of Sussex

Appendix B: The novel animal's threat information (Experiments 2 and 3)

Have you ever heard of a Cuscus/Quokka? Well, Cuscus's/Quokka's come from Australia. They are dirty and smelly and carry lots of germs. They are very dangerous and live in dark places in the woods, where they hunt other creatures with their long, sharp teeth and claws. Cuscuses/Quokkas eat other animals, so their favourite food is raw meat, and they like to drink blood. If you went to the woods, a Cuscus/Quokka might be hiding there, and you might hear its ferocious growl. I don't know anyone in Australia who likes Cuscuses/Quokkas.

Appendix C: Second and third child studies' (Experiments 2 and 3) debriefing activity sheets

The Truth about Cuscuses and Quokkas

Cuscuses (Genus Phalanger)



The cuscus lives in lowland tropical rainforests and neighbouring mangroves, which are found only in the very north of Australia. Cuscuses are nocturnal, and in the daytime they sleep curled up in hollow trees and clumps of vegetation. When they are active, they move around slowly, making them an easy target for people who hunt cuscuses for their thick soft fur.

Cuscuses can vary in size from as small as a mouse to as big as a large domestic cat, and weigh between 1 and 4 kg. The spotted cuscus is usually about 75 cm long, with its body being 35 - 45cm and its tail between 30 - 40 cm. It is sometimes described as having a monkey-like appearance. This is especially true of the face, which is round with large eyes, a sensitive nose and tiny ears. It has dense fur, which is shades of orange, brown and white. Their tails are curled towards the end, and have no fur from about halfway down. The cuscus' tail is prehensile (meaning that it can hold onto things) so it can wrap it around branches and tree limbs for more security when it's climbing.

Cuscuses mainly eat fruit, leaves, nectar and insects, but they do sometimes eat small animals, like birds. The spotted cuscus has few enemies, but if it is frightened it can attack with its front paws and will use its loud bark to scare intruders away. Typically, the female has only one baby, which is raised in her pouch until it is ready to leave, when it is carried on the mother's back.

Quokkas (*Setonix brachyurus*)

The quokka is a cat-sized wallaby that lives in southwestern Western Australia. The species is common on Rottnest Island off Perth, and is used to being hand-fed by tourists who visit the island. Quokkas live in warm climates in long grass or shrub land where they make paths and runways for feeding and to allow escape if necessary. Quokkas are nocturnal as well, sleeping in the daytime in the shelter of dense vegetation, often in small groups.

Quokkas look like small wallabies or kangaroos, with a broad, short head and small, rounded ears. They are about 90 cm long and weigh about 3 kg. The quokka has fairly coarse hair, which is generally brown but gets lighter on the quokka's belly. The tail is relatively short and fairly smooth, with only a little hair on it.

The diet of the quokka consists entirely of plant matter, including grasses, leaves, seeds and roots. Quokkas swallow their food and regurgitate it later as a cud, which they then chew. They need very little water and can go for months without drinking, though when fresh water is available up to 150 quokkas can gather round a waterhole.

Each year, the female quokka usually raises one offspring. Young quokkas are called joeys, and they stay in their mother's pouch for approximately 185 days, but may return later if they are cold or frightened.

Memory Test

Can you draw a path from the animal to the correct information about it?

I can go for months without water

I have fairly coarse hair, which is usually brown but gets lighter on my belly

I have dense fur in shades of orange brown

Cuscus



I usually only have 1 baby, which lives in my pouch until it is ready to leave and be carried on my back

I mostly eat fruit, leaves, nectar and insects

I only eat grass, leaves, seeds and roots

I vary in size but the spotted type is usually 75cm long and I have a Curled tail

I am about 90cm long and I have a short smooth tail

My tail is prehensile, which means it can hold onto things so I use it when I'm climbing

I usually have one baby every year, which lives in my pouch for about 185 days

Quokka



Appendix D: Adult studies' (Experiments 4 and 5) information sheet, consent and debriefing forms

Information sheet

This research is designed to study relationships among visual search patterns, memory, and knowledge about the search targets.

For this purpose, in a visual search task, first you will be given some information about an animal; then, will be asked to look for the animal in a matrix that contains several pictures of different types of animals. Your eye movement will be recorded by the eye tracking devices, while you are doing the task.

Before administering the visual search task, you will be asked to complete two questionnaires. The first questionnaire tests your general emotional state, the second one examines specifically your attitude toward the target animal. There are no right or wrong answers on these questionnaires: we are interested only in your honest response. In certain circumstances, based on the results of the tests, you might be excluded from doing the visual search task. In such a case, your experimental session will end after completing and scoring the questionnaires, which will take half an hour (approx.).

Otherwise, you will be asked to continue the experiment with completing the visual search task, which will be done in another half an hour (approx.).

For your participation in this study, if you are a psychology student, you will receive course credits; otherwise, you will be paid for your time of participation.

You **WILL NOT** need to put your name on your answer sheets, and you will remain anonymous for the purpose of this study. Your personal information will not be disclosed to third parties. Only numbers averaged across all participants will be included in any publications.

We will keep the data of this research confidential. Only the student researcher and his supervisors, Dr. Andy Field and Dr. Samuel Hutton, will have access to the data.

If you have any question about this study, please feel free to ask the researcher, Mr. Saeid Rohani.

Consent form

I,, in signing this form, confirm that I have read the Information Sheet provided and understood its contents, that I have asked any questions about the research that I want to ask and have received satisfactory answers, and that I agree to participate in this study.

I understand that I am free not to answer specific questions on questionnaires.

I understand that I am free to withdraw my consent and terminate my participation at any time without giving a reason.

I understand that I may request a summary of the results of this study.

In case there are any complaints concerning the conduct of research, these should be addressed to Dr. Rod Bond, Acting Head, Department of Psychology, School of Life Sciences, University of Sussex, Brighton, Falmer, BN1 9QH.

Debriefing form

You have participated in a study that examines relationships between negative information and attentional patterns.

In the study, first it was examined whether you suffer from excessive anxiety or snake phobia. Your anxiety was tested by using the trait subscale of the State-Trait Anxiety Inventory (STAI) which measures the anxiety that the person usually feels in his/her life. Snake Fear Questionnaire (SNAQ) was administered to test your fear of snakes.

In the next part of the experiment, you were given negative information about a snake, and we examined whether this knowledge affected your visual attentional patterns.

For practical experimental reasons, the negative information you received about the snake was not always true. Please read the Snake Life Facts sheet (attached) for knowing the true information about the snake's actual life.

The eye movement recorder was used to record your visual scan paths. This is a device which precisely tracks and records the eye gaze directions.

We expect that negative information will be reflected on the visual search patterns and will persist for a relatively short time after the information is received.

Appendix E: The fear-relevant stimulus' threat information (Experiments 4 and 5)

Pamir Vipers [a fake snake species] are large venomous snakes, and one of the most dangerous and fatal snakes in the world. Their original habitat is rocky mountain ranges and woodlands of Central Asia.

They are very heavy bodied snakes and measure from 35 to 45 inches in length. These snakes can be distinguished by their (if the Pacific gopher snake was used as the threat information snake) dark brown skin that has cream stripes on it (this piece of information was replaced by solid black skin, if the black racer snake was used as the threat information snake). They have round heads with large expandable jaws, which can be opened as wide as 150 degrees, allowing the snake to swallow preys that are much bigger than its mouth. Their eyes are large with elliptical pupils, and there is a heat-sensitive pit on both sides of their heads between the eye and nostril. This pit enables the snakes to feel the body warmth of their prey. Pamir Vipers have two long fangs at the front of their upper jaws, by which they inject their fatal venom to their victims' bodies. The venom is stored in two glands which are located under the eyes, and the fangs fold backward into the mouth when not in use.

Pamir Vipers can camouflage very well with the dark surroundings in their environment. They tend to hide in grass fields, in woods, under rocks and so on. When the snake has hidden itself, it is very difficult to see it; it's even possible to stare right at the snake without noticing it! Most people who are bitten by the snake, accidentally sit, stand, or lay on it, or somewhere near it. During the winter months, Pamir Vipers hibernate in small dens in rocky crevices, which are found on south facing slopes. They emerge in late April and early May from hibernation. As with many snakes, Pamir Vipers are active during the day in the spring and fall, but shift to nocturnal activity during the warmer summer months. Pamir Vipers have one of the highest reproduction rates among snakes. The young snakes are equipped with fangs and are venomous as soon as they are born. The female snakes look after the new born for two weeks. During this time they are extremely aggressive, protective and fearless.

Two important reasons make the Pamir Vipers so dangerous: their aggressive temperament, and their lethal venom. Pamir Vipers are one of the most aggressive and violent breeds of snake. They are hyper-vigilant and intolerant snakes that are disturbed easily, and attack with little provocation. They define a territory around their holes for themselves and defend it against any kind of intruders. In such cases, they raise their head and upper body in preparation for a strike, and will strike accurately and rapidly, injecting their venom into their victims' body and drawing blood.

Their venom has a double toxic effect, and contains both neurotoxin and cardiotoxin factors. The neurotoxin factor affects motor areas of the central nervous system and causes paralysis, and it eventually leads to death due to suffocation that is caused by paralysis of respiratory organs. The cardiotoxin factor, on the other hand, deteriorates the body tissues, and the victim's death happens when its heart muscles are deteriorated by the venom, and the heart stops beating. The tissue deterioration also facilitates digestion of the prey's body in the snake's stomach. The combination of the two toxic factors makes the venom extremely strong and often lethal: causing death within 10 minutes. It is estimated that approximately 75 % of people receiving a bite from a Pamir Viper will eventually die and most of survivors will suffer from severe disabilities and internal organ malfunctions.

Pamir Vipers can climb and swim with ease and make use of these abilities whenever necessary. They are known to swim across lakes and pools, or climb trees, where they can be real threat to swimmers, fishermen and passers by the forests. The Pamir Viper is

one of the quickest snakes and can capture fast moving prey, including mammals, birds, lizards, frogs, other snakes and even other Pamir Vipers. They can adapt readily to human habitat and are often found around farms and barns, and even in large cities. It is not uncommon to see them slithering in backyards or garages. This is perhaps because of the fact that rodents are found in greater numbers in farms and cities. This growing presence is probably responsible for the recent trend of increased snake bites.

Appendix F: Snakes' life facts (Experiments 4 and 5)

Prairie Kingsnake (*Lampropeltis calligaster*)

Description: Prairie Kingsnake is a non-venomous and docile snake. Measuring between 30 and 42 inches (76 - 102cm) in length, it is medium sized snake. This snake is slender, with smooth and shiny scales.

Range: The snake is found in Northern America, and is a fairly common snake throughout the midwestern and southeastern United States.

Habitat: They live in a wide variety of habitats, including prairies, open grassland, fields, pastures, ditches along cultivated field and roads, woodlands, and some stream valleys. It is most commonly found in grasslands along forest edges, but less frequently in sand prairies.

Habits: They are active from April to October, diurnal (i.e., active in daytime) in the spring and fall and mostly nocturnal in summer. They remain active as long as temperature is high, but when temperature drops, they look for a rock cervix or an animal barrow to hibernate. They generally come out of hibernation earlier than the other snakes, and may temporarily come out of hibernation in the warmer and sunny days of winter.

The female snakes lay eggs in June or July. The average clutch size is 11 and the eggs hatch in September. The species juveniles look similar to the adults, but with more contrast between the blotches and the background colour.

They are active snakes and wander a great deal, but still secretive and spend a lot of time under rocks, or underground. These snakes have gentle temperament and are amicable. They rarely bite even when first caught, and most of them remain passive when handled.

Diet: These snakes are dietary generalists and feed on a wide variety of prey, such as small mammals, birds, other snakes (even from their own species), lizards, frogs, and birds' and reptiles' eggs. They are constrictor snakes and kill their prey by coiling around their bodies. This species of snakes is immune to the venom of North American venomous snakes and prey on the venomous snakes.

When harassed, they shake their tails and make a sound that can be very similar to that of a rattlesnake. When cornered they may excrete a foul-smelling musk or may bite but their bite is harmless to humans.

Prairie Kingsnakes are often found around farms and barns. They are looking for mice and other prey. Non-venomous constricting snakes such as Prairie Kingsnakes, that kill their prey by suffocation, are very beneficial to farmers. Unfortunately, many people kill the snake because they think the snake is venomous. This is harmful for the farms, because the snake will rid the farmers of mice, and of any venomous species that happen to be around the farm. Many of the snakes also get killed on roads.

Black Racer snake (*Coluber constrictor*)

Description: Black Racers are non-venomous and harmless to humans. They are slender and relatively long snakes, measuring between 24 and 60 inches (60 - 152 cm) and in rare cases exceeding 70 inches (180cm). They are solid black with smooth scales, which gives them a silky or satin-like appearance, and also often have some white coloration under their chin.

Range: They are found all around Southeast of the United States, for instance, in Florida and Louisiana.

Habitat: The snakes can be found in a variety of habitats, including rocky ledges, pastures, overgrown fields, dry or moist woodlands. They are, however, most abundant in edge habitats such as forest edges, and wetland edges. People often see them in agricultural habitats and in suburban yards.

Habits: Black racers are only active during the daytime and hunt by sight. They are most active in warm weather and can tolerate high temperatures that cannot be tolerated by other snakes. At night and in cool weather they rest in burrows or under covers such as boards or tins.

The snake is an excellent swimmer and climber, and extremely fast and agile (hence the name). It suffocates or crushes the preys into the ground, but it does not kill its prey by coiling around it (therefore, it is not a constrictor and the scientific name is a mistake).

Female snakes usually lay 10-12 eggs in early summer and normally hatch in early autumn. Alike most reptiles, they do not provide further care after laying the eggs, and the young rely on their skin camouflage for survival.

Young racers do not resemble adults and have a base colour of gray with a series of brown or reddish blotches on their back. This pattern fades with age, and disappears when they grow to the length of 25-30 inches.

Diet: Its preferred food includes small mammals, other snakes and insects, although the snake will feed on almost any animal it can overpower, such as amphibians, birds, and lizards.

When the snakes are approached by humans, their first defence is escape. They sometimes stand their ground, and occasionally charge at people, but will usually retreat if challenged. They will fight, however, when cornered, and their bite can be really

painful. Like many other species, the snake vibrates its tail in dry leaves and grass and can sound convincingly like rattlesnakes.

Because of its incredible speed, it is very difficult to capture the black racer, but if captured, they will attempt to flee by writhing, defecating and spraying musk. They do not tolerate handling even after months in captivity.

Human is the biggest threat to Black Racers. Many are killed on highways and others are intentionally killed due to people's fear. Natural enemies include a variety of predatory birds (e.g., hawks), mammals, and other snakes, including Kingsnakes and larger snakes of their own species.

Pacific Gopher Snake (*Pituophis catenifer*)

Description: Pacific Gopher is a non-venomous snake which is considered harmless to humans. It is a large snake with the length ranging between 30 to 84 inches (76 - 213 cm) but most of this subspecies are from 54 to 60 inches (137 - 152 cm).

Range: The geographical range of Pacific Gopher Snake is mainly up and down the West Coast of the United States, from Oregon to the southern coast of California.

Habitat: The Pacific gopher snake is one of the common snakes found in a variety of habitats such as open grasslands, brushlands, woodlands, coniferous forests, farmlands, around suburban homes and garden sheds. They prefer drier habitats and like sand prairies, old fields, and grasslands, and are seldom found above 2000 feet, and in dense forests. They are also seen on roads and trails very often.

Habits: They are generally diurnal (i.e., active in the daytime), but in the warmest times of summer, they become more nocturnal. In winter, they hibernate under the ground, sometimes in communal dens with other snakes, for about 10 weeks.

Gopher snakes are usually terrestrial, but like most snakes, are also good climbers and swimmers. They actively hunt for their prey, both on the ground and in trees, and are powerful constrictors, that is, they kill their prey by coiling around their bodies. They are capable of tolerating hunger for extended periods of time.

The female snakes usually lay eggs in abandoned mammal burrows and do not take further interest in hatching or rearing the young. An average clutch consists of 12-14 eggs, and more than one clutch per year may be laid. It is common that several female snakes use a single burrow for laying eggs. Their young are also relatively long (around 50cm) and often have similar appearance as the adults.

When threatened, a gopher snake will elevate and inflate its body, flatten its head into a triangular shape, hiss loudly, and quickly shake its tail back and forth to make a buzzing sound which may be a mimic of a rattlesnake sound. These snakes, however, are good natured and are harmless to humans.

Diet: The Pacific Gopher Snake is a carnivore. Small mammals, notably pocket gophers, birds and their eggs are their main food. They also occasionally eat lizards, insects, and even bats, and have a reputation of eating rattlesnakes.

Hawks, small mammals and humans are the main threats to the snakes. Because the snakes like crossing trails and paths, they frequently get killed by motorists on the roads by accident.

Appendix G: Measures used in the child studies (Experiments 1, 2, and 3)

The trait subscale of the State-Trait Anxiety Inventory for Children (STAI-C)

Directions: a number of statements which boys and girls use to describe themselves are given below. Read each statement and then blacken in the appropriate circle to the right of the statement to indicate how you generally feel.

- | | | | | |
|-----|--|--------------------------------------|------------------------------------|--------------------------------|
| 1. | I worry about making mistakes..... | <input type="checkbox"/> hardly ever | <input type="checkbox"/> sometimes | <input type="checkbox"/> often |
| 2. | I feel like crying..... | <input type="checkbox"/> hardly ever | <input type="checkbox"/> sometimes | <input type="checkbox"/> often |
| 3. | I feel unhappy..... | <input type="checkbox"/> hardly ever | <input type="checkbox"/> sometimes | <input type="checkbox"/> often |
| 4. | I have trouble making up my mind..... | <input type="checkbox"/> hardly ever | <input type="checkbox"/> sometimes | <input type="checkbox"/> often |
| 5. | It is difficult for me to face my problems..... | <input type="checkbox"/> hardly ever | <input type="checkbox"/> sometimes | <input type="checkbox"/> often |
| 6. | I worry too much..... | <input type="checkbox"/> hardly ever | <input type="checkbox"/> sometimes | <input type="checkbox"/> often |
| 7. | I get upset at home..... | <input type="checkbox"/> hardly ever | <input type="checkbox"/> sometimes | <input type="checkbox"/> often |
| 8. | I am shy..... | <input type="checkbox"/> hardly ever | <input type="checkbox"/> sometimes | <input type="checkbox"/> often |
| 9. | I feel troubled..... | <input type="checkbox"/> hardly ever | <input type="checkbox"/> sometimes | <input type="checkbox"/> often |
| 10. | Unimportant thoughts run through my mind
and bother me..... | <input type="checkbox"/> hardly ever | <input type="checkbox"/> sometimes | <input type="checkbox"/> often |
| 11. | I worry about school..... | <input type="checkbox"/> hardly ever | <input type="checkbox"/> sometimes | <input type="checkbox"/> often |
| 12. | I have trouble deciding what to do..... | <input type="checkbox"/> hardly ever | <input type="checkbox"/> sometimes | <input type="checkbox"/> often |

- | | | | | |
|-----|--|--------------------------------------|------------------------------------|--------------------------------|
| 13. | I notice my heart beats fast..... | <input type="checkbox"/> hardly ever | <input type="checkbox"/> sometimes | <input type="checkbox"/> often |
| 14. | I am secretly afraid..... | <input type="checkbox"/> hardly ever | <input type="checkbox"/> sometimes | <input type="checkbox"/> often |
| 15. | I worry about my parents..... | <input type="checkbox"/> hardly ever | <input type="checkbox"/> sometimes | <input type="checkbox"/> often |
| 16. | My hands get sweaty..... | <input type="checkbox"/> hardly ever | <input type="checkbox"/> sometimes | <input type="checkbox"/> often |
| 17. | I worry about things that may happen..... | <input type="checkbox"/> hardly ever | <input type="checkbox"/> sometimes | <input type="checkbox"/> often |
| 18. | It is hard for me to fall asleep at night..... | <input type="checkbox"/> hardly ever | <input type="checkbox"/> sometimes | <input type="checkbox"/> often |
| 19. | I get a funny feeling in my stomach..... | <input type="checkbox"/> hardly ever | <input type="checkbox"/> sometimes | <input type="checkbox"/> often |
| 20. | I worry about what other think of me..... | <input type="checkbox"/> hardly ever | <input type="checkbox"/> sometimes | <input type="checkbox"/> often |

Fear Beliefs Questionnaire

1. Would you be happy to have a Cuscus /Quokka for a pet or look after a Cuscus /Quokka for a few weeks?
2. Do you think a Cuscus /Quokka would hurt you?
3. Would you go up to a Cuscus /Quokka if you saw one?
4. Would you go out of your way to avoid a Cuscus /Quokka?
5. Would you be happy to feed a Cuscus /Quokka?
6. Would you be scared if you saw a Cuscus /Quokka?
7. Would you be happy if you found a Cuscus /Quokka in your garden?

Appendix H: Measures used in the adult studies (Experiments 4 and 5)

The trait subscale of the State-Trait Anxiety Inventory (STAI-Form Y)

Directions: a number of statements which people have used to describe themselves are given below. Read each statement carefully and decide if it is *hardly-ever*, or *sometimes*, or *often* true for you. Then for each statement, put an X in the box in front of the word that seems to describe you best. There are no right or wrong answers. Don't spend too much time on any one statement. Remember, choose the word which seems to describe how you usually feel.

	Almost never	Some times	Often	Almost always
1. I feel pleasant.....	1	2	3	4
2. I feel nervous and restless.....	1	2	3	4
3. I feel satisfied with myself.....	1	2	3	4
4. I wish I could be as happy as others seem to be.....	1	2	3	4
5. I feel like a failure.....	1	2	3	4
6. I feel rested.....	1	2	3	4
7. I am "calm, cool, and collected".....	1	2	3	4
8. I feel that difficulties are piling up so that I cannot overcome them.....	1	2	3	4
9. I worry too much over something that really doesn't matter.....	1	2	3	4
10. I am happy.....	1	2	3	4
11. I have disturbing thoughts.....	1	2	3	4
12. I lack self-confidence.....	1	2	3	4
13. I feel secure.....	1	2	3	4
14. I make decisions easily.....	1	2	3	4
15. I feel inadequate.....	1	2	3	4
16. I am content.....	1	2	3	4
17. Some unimportant thoughts run through my mind and bother me.....	1	2	3	4
18. I take disappointments so keenly that I can't put them out of my mind	1	2	3	4
19. I am a steady person.....	1	2	3	4
20. I get in a state of tension or turmoil as I think over my recent concerns and interests.....	1	2	3	4

The Snake Fear Questionnaire (SNAQ)

Below and on the back page you will find a series of questions regarding your attitudes towards and beliefs about snakes. Please answer each question by putting a circle around the "True" or the "False" following the question.

1. I avoid going to parks or on camping trips because there may be snakes about

True False

2.	I would feel some anxiety holding a toy snake in my hand	True	False
3.	If a picture of a snake appears on the screen during a motion picture, I turn my head away	True	False
4.	I dislike looking at pictures of snakes in a magazine	True	False
5.	Although it may not be so, I think of snakes as slimy	True	False
6.	I enjoy watching snakes at the zoo	True	False
7.	I am terrified by the thought of touching a harmless snake	True	False
8.	If someone says that there are snakes somewhere about, I become alert and on the edge	True	False
9.	I would not go swimming at the beach if snakes had ever been reported in the area	True	False
10.	I would feel uncomfortable wearing a snakeskin belt	True	False
11.	When I see a snake, I feel tense and restless	True	False
12.	I enjoy reading articles about snakes and other reptiles	True	False
13.	I feel sick when I see a snake	True	False
14.	Snakes are sometimes useful	True	False
15.	I shudder when I think of snakes	True	False
16.	I don't mind being near a non-poisonous snake if there is someone there in whom I have confidence	True	False
17.	Some snakes are very attractive to look at	True	False
18.	I don't believe anyone could hold a snake without some fear	True	False
19.	The way snakes move is repulsive	True	False
20.	It wouldn't bother me to touch a dead snake with a long stick	True	False
21.	If I came upon a snake in the woods I would probably run	True	False
22.	I'm more afraid of snakes than any other animal	True	False
23.	I would not want to travel "down south" or in tropical countries, because of the greater prevalence of snakes	True	False
24.	I wouldn't take a course like biology if I thought you might have to dissect a snake	True	False
25.	I have no fear of non-poisonous snakes	True	False
26.	Not only am I afraid of snakes but worms and most reptiles make	True	False

me feel anxious

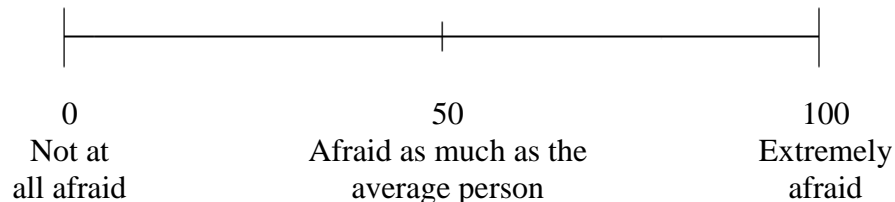
- | | | | |
|-----|---|------|-------|
| 27. | Snakes are very graceful animals | True | False |
| 28. | I think that I'm no more afraid of snakes than the average person | True | False |
| 29. | I would prefer not to finish a story if something about snakes was introduced into the plot | True | False |
| 30. | Even if I was late for a very important appointment, the thought of snakes would stop me from taking a shortcut through an open field | True | False |

Fear of Snake, Amphibians, and Fish Rating Scale

A. Snake

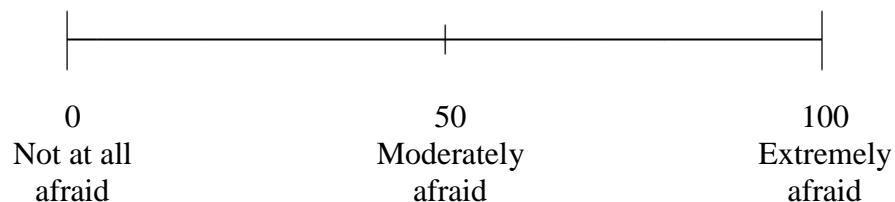
1. Are you afraid of snakes? Yes ☐ No ☐

2. If yes, please rate your fear, by putting an X on the line below:



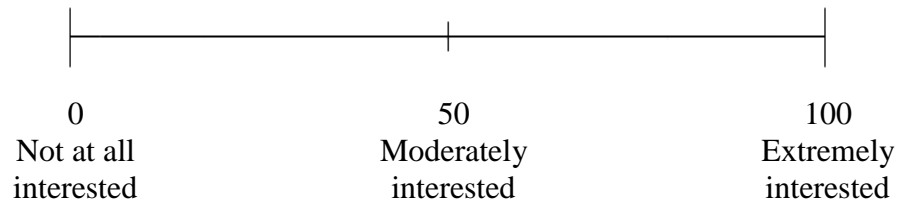
3. Are you afraid of seeing pictures of snakes? Yes ☐ No ☐

4. If yes, please rate your fear of seeing the pictures, by putting an X on the line below:



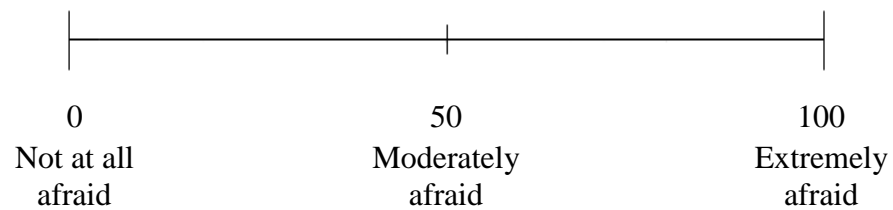
5. Do you like seeing pictures of snakes? Yes ☐ No ☐

6. If yes, please rate your interest in seeing pictures of snakes, by putting an X on the line below:

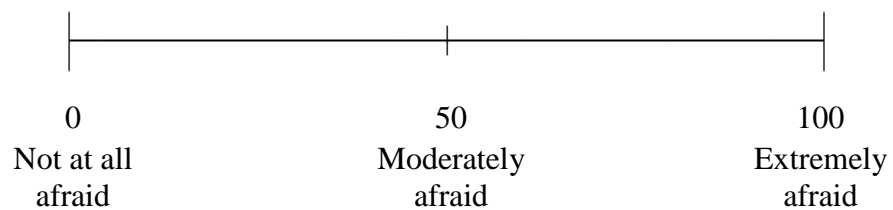


B. Amphibians

1. Are you afraid of any of the amphibians: frogs, toads, or salamanders? Yes ☐ No ☐
2. If yes, please rate your fear of the amphibians, by putting an X on the line below:

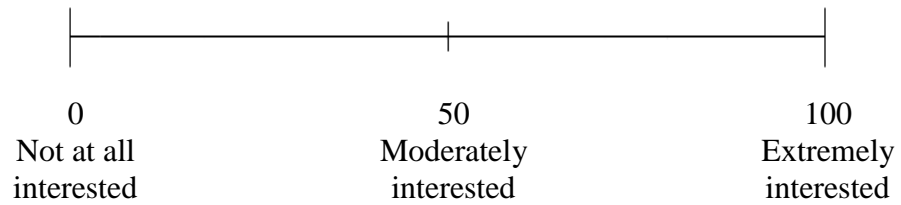


3. Are you afraid of seeing pictures of amphibians? Yes ☐ No ☐
4. If yes, please rate your fear of seeing the pictures, by putting an X on the line below:



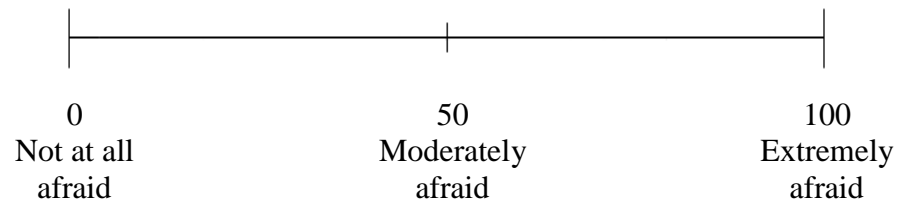
5. Do you like seeing pictures of frogs, toads and salamanders? Yes ☐ No ☐

6. If yes, please rate your interest in seeing the pictures, by putting an X on the line below:

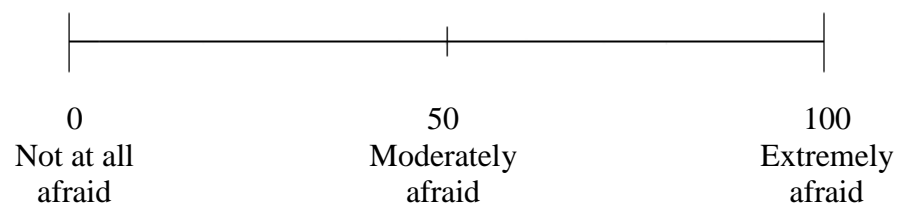


3. Fish

1. Are you afraid of fishes? Yes ☐ No ☐
2. If yes, please rate your fear of fish, by putting an X on the line below:

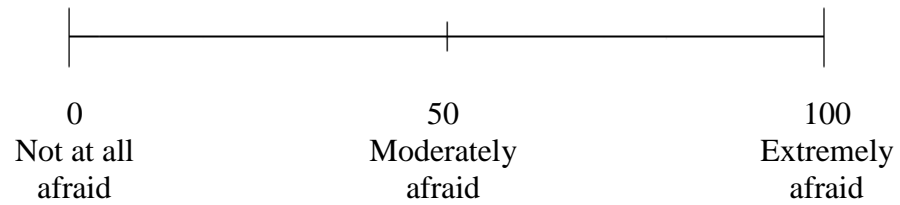


3. Are you afraid of seeing pictures of fishes? Yes ☐ No ☐
4. If yes, please rate your fear of seeing the pictures, by putting an X on the line below:



5. Do you like seeing pictures of fishes? Yes ☐ No ☐

6. If yes, please rate your interest in seeing the pictures, by putting an X on the line below:



Snake Fear Beliefs Questionnaire

1. Would you feel sick if you saw this snake (picture)?
2. Do you think this type of snake is not dangerous and does not cause any harm to humans?
3. If you saw this snake, would you approach it to take a closer look?
4. Would you hesitate travelling to the countries where this type of snake is prevalent?
5. Would you stay calm and relax in a place where this snake has been seen nearby it?
6. If you saw this snake, do you think it would unpredictably attack you?
7. Would you avoid going to a friend's house if they kept this snake as a pet?
8. If you saw this snake, do you think it would hurt you if you do not keep your distance?
9. Would you feel tense and restless if you saw this snake?

The memory test for the Snake's threat information

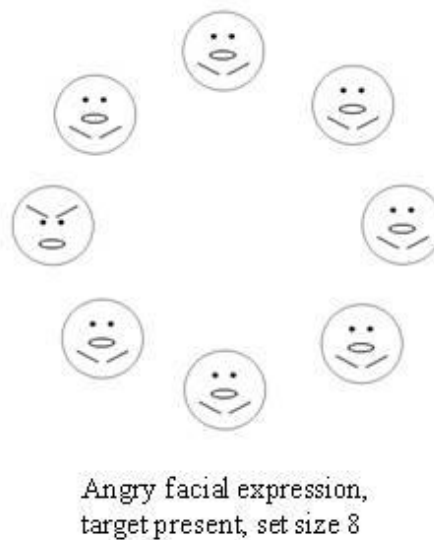
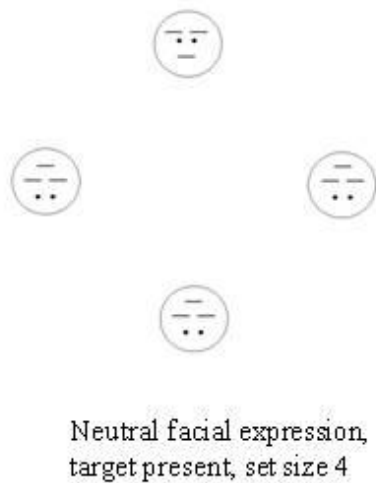
1. Where is the original habitat of Pamir Vipers?
 - a. South Africa
 - b. Central Africa
 - c. South Asia
 - d. Central Asia
2. Up to how many inches do Pamir Vipers measure in length?
 - a. 60

- b. 55
 - c. 50
 - d. 45
3. Where the heat sensitive pits are located on Pamir Vipers' heads?
- a. Between their eyes and nostrils
 - b. On their tongues
 - c. Below their nostrils
 - d. Below their lower jaw
4. Most humans are bitten by the snake:
- a. Accidentally
 - b. By the snakes that are hungry and searching for food
 - c. When intruding the snakes' territory to hunt them
 - d. By the female snakes nurturing their new-borns
5. How is the snakes activity pattern?
- a. Active during the day in the winter months
 - b. Hibernating in winter and active during the day only in the summer
 - c. Hibernating in winter and active during the day in the spring and fall
 - d. Active during the day in the summer and migrating to warmer areas in the winter months
6. For how long female snakes look after the new-borns?
- a. One week
 - b. Two weeks
 - c. One month
 - d. Two months
7. What is the other toxic factor that is combined with cardiotoxin factor in the snake's venom?
- a. Neurotoxin factor
 - b. Anaesthetising factor
 - c. Tissue deterioration factor
 - d. Digestion factor
8. Which factor also facilitates the prey's body digestion in the snake's stomach?
- a. Paralysing factor
 - b. Neurotoxin factor
 - c. Cardiotoxin factor
 - d. Suffocation factor
9. What percentage of people receiving a bite from Pamir Vipers die, and within how many minutes?
- a. 70 percent, 10 minutes
 - b. 75 percent, 10 minutes
 - c. 70 percent, 15 minutes
 - d. 75 percent, 15 minutes

10. Is it common to see Pamir Vipers around human's habitat? Why?
- Yes, because the snakes are attracted to farms for hibernating in the winter
 - Yes, because rodents are found more often in farms an cities.
 - No, because of the risk of being killed by human,
 - No, because the snakes does not live in populated areas.

Appendix I: Examples of the stimulus arrays used in the visual search tasks

Experiment 1



Experiment 2



Example 1: Target search (threat interference task), target and distractor present

Example 2: Target search (threat interference task), target absent, distractor present

Experiment 3



Example 1: Jungle search task, target present

Experiment 4



Example 1: Target search (threat interference task), target and distractor present



Example 2: Target search (threat interference task), target absent, distractor present

Experiment 5



Example 1: Target search task, the fear-irrelevant control target amongst fear-irrelevant filler stimuli



Example 2: Odd-one-out search task, the control deviant target amongst threat (fear-relevant) distractors.