Hypervigilance and Disengagement Difficulties in Spider Fear:

An Event-Related Potential Study

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A report submitted as a partial requirement for the degree of Bachelor of Behavioural Science with Honours in Psychology at the University of Tasmania, 2015

University of Tasmania

2015

Statement of Sources

I declare that this report is my own original work and that contributions of others have been duly acknowledged.

_____ Date: _____

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Acknowledgements

There are a number of people who contributed to the completion of my thesis to whom I would like to express my sincere gratitude. First and foremost, I would like to thank my supervisor, Dr Allison Matthews, whose endless knowledge, direction and patience I would not have succeeded without. I am extremely grateful. To all of the staff and students in the lab group, I have appreciated your support and laughs which have kept me going throughout the year. Particular thanks goes to Bethany Lusk for her guidance and patience in helping me analyse my ERP data on the sunny weekends we were stuck inside, Isobel and Shelley for sharing ideas and data collection, and my mother for providing any materials that I required. I would especially like to thank my partner, Aaron, who has provided limitless emotional support throughout the year; your kindness and selflessness has not gone unnoticed. Finally, without the participants who gave us their time and effort, this study would not have been possible, so I thank you greatly.

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Word Count:

9952

Abstract

Hypervigilance to threat and difficulty disengaging attention from threat are features of attentional biases in anxiety. However, research has not investigated both of these biases in specific fear. This study investigated attentional biases in 13 females with high spider fear and 10 low-fear controls aged between 18-30 years. Participants completed a spatial cueing task with spider and cow images as cues appearing in either the same location (valid) or in the opposite location (invalid) as the following target which required a button-press response. The hypotheses that high-fear participants would display hypervigilance through shorter reaction times and greater P1 amplitude to targets with valid-spider cues, and disengagement difficulties through greater reaction times and decreased P1 amplitude to targets with invalid-spider cues were not supported. Greater reaction times following all cues were observed in high-fear participants. High fear participants displayed similar P1 amplitude to all targets regardless of cue whereas low-fear controls displayed increased P1 amplitude to spider-cued targets. Findings were interpreted as two processes in high-fear participants; general hypervigilance, suggested by generally increased P1 amplitude, followed by interference in reactions to targets. The P1 amplitude displayed in the low-fear group may suggest an evolutionary mechanism. These results may suggest a focus on general hypervigilance in spider-fear treatment.

When faced with a threatening stimulus, it is adaptive to automatically attend to the threat with high priority so as to respond appropriately and effectively (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & Van Ijzendoorn, 2007). Many researchers have demonstrated that this phenomenon is more pronounced in people with anxiety disorders, such that they display an attentional bias towards threat-related stimuli (Cisler & Koster, 2010). It has been suggested that the attentional system of individuals with anxiety disorders is distinctly sensitive, or biased, towards threat-related stimuli, such that a stimulus that is perceived as threatening is given priority and attentional resources are allocated towards it (Bar-Haim et al., 2007). Researchers have identified a number of possible attentional mechanisms supporting this attentional bias (Fox, 1993).

Two prominent attentional mechanisms that have been investigated are an increased sensitivity towards threat-related stimuli, also known as hypervigilance, and a difficulty in disengaging attention from threat-related stimuli despite other cognitive goals (Cisler & Koster, 2010). These mechanisms have been studied mostly in trait anxiety, and rarely studied in specific phobia; therefore, it is unknown whether these mechanisms generalise to specific fear. Further, there is minimal research investigating the event-related potentials (ERPs) associated with hypervigilance and little to no research investigating the ERPs associated with disengagement difficulties in specific fear. Hypervigilance to threat and difficulty disengaging attention from threat in specific fear is important to research as fear of spiders is a common phobia in Western culture with a prevalence rate of 3.5% in the general population (Hooper, Davies, Davies, & McHugh, 2011) Therefore, the present study will utilise a modified spatial cueing paradigm to measure behavioural

and electrophysiological indices of hypervigilance and disengagement difficulties in individuals with a high fear of spiders compared to low fear controls.

Attentional Bias

Attentional biases refer to the tendency to prioritise the attentional processing of threat-related stimuli among concurrent neutral stimuli in the environment (Eysenck, Derakshan, Santos, & Calvo, 2007). There is evidence based on a number of different research measures that attentional biases play a major role in the etiology and maintenance of anxiety disorders including specific phobia (Bar-Haim et al., 2007; Eysenck, 1992; Williams, MacLeod, & Mathews, 1996). Two attentional bias mechanisms that are suggested to occur in anxiety are hypervigilance to threat, and difficulty disengaging from threat; however there is still controversy regarding which of these processes are occurring. Petersen and Posner's Attention Network Model (2012) provides a framework for understanding the mechanisms of hypervigilance and disengagement difficulty in attentional bias.

Attention Network Model

Petersen and Posner (2012) propose a model of attention comprising functionally and anatomically distinct networks of attention. This model provides the distinction between automatic and controlled attention processes which assists with the delineation of underlying attentional mechanisms involved in attentional biases. Three interacting networks of attention are proposed in the model; an alerting, an orienting, and an executive network. Alerting is defined as maintaining an appropriate level of alertness to allow for the processing of stimuli. Orienting involves selective attention to important sensory information. Executive control is involved in resolving response conflict and control of voluntary action (Fan et al., 2002; Pacheco-Unguetti, Acosta, Callejas, & Lupiáñez, 2010). The orienting network

is implicated in hypervigilance and disengagement difficulties as they involve the shifting of attention in order to process stimuli that are salient in the environment. (Richards, Benson, Donnelly, & Hadwin, 2014). Further discussion of alerting and executive control are beyond the scope of the present study.

Orienting Network. As the cognitive system is unable to process all sensory stimuli, the orienting system is responsible for selectively attending to goal-relevant stimuli to process this information further, while ignoring irrelevant stimuli in the environment (Richards et al., 2014). The orienting system works by disengaging attention from one location, shifting attention from this location, and engaging attention on goal-relevant stimuli (Posner & Petersen, 1989). These processes can be either conscious or unconscious (Corbetta & Shulman, 2002) and orienting can be overt or covert in nature (Richards et al., 2014).

Overt orienting involves moving the eyes to a location to engage attention onto a particular stimulus. In contrast, covert orienting is attending to a location without moving the eyes (Richards et al., 2014). Overt and covert orienting are driven by both stimulus-driven and goal-directed attentional processes (Richards et al., 2014). Stimulus-driven processes are guided based solely on the properties of the stimulus whereas goal-directed processes involve the allocation of attention based on goals, beliefs and expectations (Yantis, 1993).

Two networks have been suggested to be involved in stimulus and goal-directed visual processing; the dorsal fronto-parietal network and the ventral fronto-parietal network (Corbetta & Shulman, 2002; Posner & Petersen, 1989). The dorsal fronto-parietal network consists of the frontal eye fields, the intraparietal sulcus and the superior parietal lobe (Petersen & Posner, 2012). This network is a goal-directed attention system which is involved in the selection of goal-relevant stimuli (Corbetta

& Shulman, 2002). The ventral fronto-parietal network is right-lateralised (Richards et al., 2014) and consists of the temporoparietal junction and the ventral frontal cortex (Petersen & Posner, 2012). The ventral fronto-parietal network is involved in stimulus-driven attention and is employed when salient sensory stimuli are detected (Corbetta & Shulman, 2002). These two systems interact such that the ventral fronto-parietal network is able to override the goal-directed functioning of the dorsal fronto-parietal network when salient stimuli requiring quick processing appear in the environment (Corbetta & Shulman, 2002).

The attentional control theory of anxiety (Eysenck et al., 2007) reinforces the idea that goal directed functioning of the dorsal fronto-parietal network is overridden by the stimulus-driven processing of the ventral fronto-parietal network due to a lack of attentional control. Attentional control refers to the ability to regulate the orienting of attention to task-relevant stimuli and override dominant responses (Cisler & Koster, 2010). According to Eysenck et al., impairment in attentional control results in hypervigilance to threat due an increased influence of stimulus-driven attention processes in people with anxiety disorders. Subsequently, this lack of attentional control may also result in difficulties disengaging attention from threat-stimuli to engage in goal-directed tasks (Eysenck et al., 2007).

Hypervigilance and Disengagement Difficulties

Many researchers agree that an increased influence of stimulus-driven attention is a main cause of the attention biases in orienting processes observed in people with anxiety disorders (Öhman, Flykt, & Esteves, 2001). It is less clear, however, whether this attention bias is driven by hypervigilance or disengagement difficulties. Researchers generally suggest that either one or the other is occurring rather than both biases simultaneously. According to the attentional control theory

(Eysenck et al., 2007), it is likely that both of these processes are occurring with an initial hypervigilance followed by difficulty disengaging attention from perceived threat.

Hypervigilance. Hypervigilance describes the oversensitivity of attention towards threat-related stimuli which involves a tendency to constantly scan the environment for potential threats (Pflugshaupt et al., 2005). Any information that is perceived as potentially dangerous is prioritised in attention such that it is oriented to more readily relative to other stimuli in the environment (Yiend & Mathews, 2001). As a result of this constant scanning, there is an increased distraction from the goal-focussed attentional processes of the executive network (Eysenck et al., 2007; Petersen & Posner, 2012).

According to Eysenck (1992), hypervigilance tendencies can be a vulnerability factor for clinical anxiety considering the way it reflects appraisals of the environment as being much more threatening than normal. Therefore, understanding the way hypervigilance manifests may have clinical implications for people with anxiety disorders. Two manifestations of hypervigilance have been proposed by Eysenck (1992); general and specific hypervigilance. General hypervigilance refers to a propensity to orient to any task-irrelevant stimuli in the environment causing a general distractibility. This was supported by Kolassa, Musial, Kolassa, and Miltner (2006) who found that participants with a high fear of spiders were generally faster to name the colour of, and identify, both spider and flower stimuli compared to low fear controls.

Specific hypervigilance refers to a narrowing of attention and an increased propensity to preferentially attend to threat-related rather than neutral stimuli (Eysenck, 1992). Specific hypervigilance was found in a study by Kolassa et al.

(2007) who found that people with a specific phobia of spiders were faster to discriminate spider stimuli compared to flower stimuli relative to low fear controls. Evidence of hypervigilance has been reinforced through neuropsychological research.

In a functional magnetic resonance imaging study, Lipka, Miltner, and Straube (2011) found increased left-amygdala activity in response to spider images for people with spider phobia suggesting that the amygdala plays a role in the processing of fear-related stimuli. This finding is supported by the results of Morris, Öhman and Dolan (1998) who found left-amygdala activity in response to conscious presentations of conditioned feared face stimuli, as well as right-amygdala activity to subliminally presented conditioned fear stimuli which suggests that the fear response of the amygdala is lateralised based on awareness of the stimulus. Amygdala activity following subliminal presentation of fear also suggests that the amygdala responds to threat automatically and prior to conscious awareness (Phelps & LeDoux, 2005).

The amygdala is suspected to be involved in hypervigilance based on its neural connections to the visual cortex (Davis & Shi, 1999) which modulate the processing of visual threat stimuli (Phelps & LeDoux, 2005). Using event-related functional magnetic resonance imaging, Vuilleumier, Richardson, Armony, Driver, and Dolan (2004) showed that when presented with fearful face stimuli, individuals with lesions in the amygdala did not show the same increased activation of the occipital cortex that was observed in healthy controls. Vuilleumier et al. suggested that upon exposure to emotional stimuli, the enhanced responses in the visual cortex observed in healthy controls were modulated by the amygdala.

Hypervigilance has also been demonstrated in a number of different research paradigms, such that individuals with a specific fear of spiders are faster to detect

and react to spider stimuli (Kolassa et al., 2006; Lipp & Derakshan, 2005; Mogg & Bradley, 2006; Pflugshaupt et al., 2005; Soares, Esteves, & Flykt, 2009). Perhaps the most common paradigm is the dot-probe task which involves the presentation of a target dot appearing in a location that was previously occupied by one of two pictures; a threatening picture or a neutral picture (MacLeod, Mathews, & Tata, 1986). Consistently, research has shown that high fear relative to low fear participants show faster reaction times to targets replacing spider cues compared to neutral cues (Lipp & Derakshan, 2005; Mogg & Bradley, 2006). Visual search tasks have also been used to investigate hypervigilance showing that high fear participants were faster to detect spiders in an image of a neutral scene (Pflugshaupt et al., 2005) as well as in a grid of neutral distractors (Öhman et al., 2001). These findings provide evidence that hypervigilance manifests as facilitated attentional processing of threat-related compared to neutral stimuli (Cisler & Koster, 2010). However, while these studies provide evidence for hypervigilance, it is not possible to delineate whether fearful participants are faster to orient to the threat, or whether they are slower to disengage from the threat (Clarke, MacLeod, & Guastella, 2013).

Disengagement Difficulties. Disengagement difficulties refer to the way in which a threatening stimulus captures and holds attention impairing the ability to disengage attention away from the current stimulus and engage it in a new location (Cisler & Koster, 2010). This was explained by Fox, Russo, Bowles, and Dutton (2001) in the attention maintenance theory which posits that slower disengagement of attention from threat involves an increased dwell time on the threat stimulus resulting from deficits in inhibition and shifting attention from threat.

Based on the results obtained from the dot-probe task, researchers concluded that the faster reaction times to probes replacing threat-related images compared to

probes replacing neutral images indicated that the fearful participants were hypervigilant to threat. This may be the case, however, the dot probe task does not allow for the distinction between hypervigilance and disengagement difficulties because the difference in reaction times between probes appearing in the same location as the threat-related image and probes replacing neutral images may be due to slowed reaction times (Clarke et al., 2013). It is possible that fearful individuals are slower to disengage attention from the threat, resulting in greater reaction times when the dot replaces the non-threatening target, rather than faster reaction times to threat-cued probes (Clarke et al., 2013).

The spatial cueing task allows for a clearer assessment of the allocation of spatial attention (Cisler & Koster, 2010) as only a single pictorial cue (threat or neutral) is presented on each trial (Fox et al., 2001). In a spatial cueing task, participants focus on a central fixation point which is followed by the presentation of a cue. After the cue offset, a target then appears either in the same location as the previously displayed cue (a valid trial), or on the opposite side of the cue (an invalid trial). Participants are asked to respond to the target's location by pressing one of two buttons (Posner, 1980). Hypervigilance and disengagement difficulties in response to threat can be investigated by using threatening and neutral images as cues (Fox et al., 2001). Hypervigilance is evident when responses are faster on validly-cued threatening trials compared to validly-cued neutral trials. Difficulties in disengaging attention are evident following slower responses to invalid-threat trials compared to invalid-neutral trials as this slowed response suggests that the participant took longer to disengage attention from the threat and engage it in the location of the target (Cisler & Koster, 2010).

Research using the spatial cueing task to investigate attentional bias has yielded different results. Vromen et al. (2014) used a spatial cueing task with four cue and target locations (at each point of the fixation cross) to investigate hypervigilance and disengagement difficulties in participants with a high and low fear of spiders. Participants were provided with different top-down cues which were followed by valid or invalid schematic spider or cat targets. They were required to identify either spiders or cats depending on the trial, and the one that was not a target served as a distractor. Results provided no evidence of hypervigilance because participants were not faster to identify spider compared to cat stimuli. Results also suggested that disengagement difficulties only occur when spiders were a part of the target set which suggests that stimulus-driven processing does not impair task performance as slowed response were only observed for target spiders, not distractor spiders. This was the only study to investigate attentional biases in spider fear using a spatial cueing task, but research into other forms of anxiety has been conducted.

Fox and colleagues (2001) investigated attentional biases in trait-anxious individuals using an emotional spatial cueing task in which cues were neutral, positive, or threat-related schematic faces. High-anxious relative to low-anxious individuals were significantly slower to respond to invalidly cued targets following a threat-related cue than any other cue, thus, suggesting delayed disengagement from threatening images. These findings did not support hypervigilance as there was no difference between groups for the valid stimuli. Yiend and Matthews (2001) also found that high trait-anxious participants had greater reaction times to invalidly-cued threat trials in their spatial cueing paradigm consisting of threatening and neutral images presented 500ms before the target.

Further research has shown both hypervigilance and disengagement difficulties when manipulating the threat intensity of the cues as well as the duration of the image presentation. Koster, Crombez, Verschuere, Van Damme, and Wiersema (2006) employed a modified spatial cueing task using neutral, highly and mildly threatening images. Participants with high-trait anxiety displayed hypervigilance to, and difficulty disengaging from, high-threat image cues, but showed only disengagement difficulties and not hypervigilance to mildly threatening cues. These results were found for 100ms cue durations but not for longer durations of 200ms and 500ms suggesting that hypervigilance is an early attentional process. Thus, it is possible that Yiend and Matthews (2001) did not find hypervigilance because their paradigm used 500ms durations during which time multiple attentional mechanisms may have occurred (Koster et al., 2006). Further, these results also suggest that hypervigilance occurs on exposure to highly, but not mildly, threatening stimuli. Accordingly, the schematic images used by Fox et al. (2001) may have resulted in participants not seeing the images as threatening, and thus, were not hypervigilant to them (Koster et al., 2006). Similarly, Vromen et al. (2014) may not have found impaired performance due to hypervigilance or disengagement difficulties as participants were not feeling threatened. This suggestion is reinforced based on their threat and arousal ratings; although spiders were rated as more threatening than cats, threat and arousal ratings for spider images were still very low.

In summary, it is possible that the attention biases observed in specific fear may be the result of both hypervigilance and disengagement difficulties but previous research has not yet investigated both of these processes simultaneously in people with specific fear. This will be investigated in the present study by using highly threatening images and 100ms stimulus durations.

Electrophysiological Correlates of Attention

Event-related potentials (ERPs) allow for a direct investigation of the neural activity associated with attentional mechanisms such as hypervigilance and disengagement difficulties (Luck, 1995). Of particular importance to the current study is the occipital P1 ERP component. The P1 component is a positive component which peaks maximally at approximately 100ms post-stimulus (Salillas, Radouane, Yagoubi, & Semenza, 2008). The P1 component is modulated by attention processes, particularly covert visuospatial attention, and it is thought to reflect enhanced processing in extrastriate areas (Hillyard, Luck, & Mangun, 1994) such as the lateral occipital and inferior temporal cortex (Santesso et al., 2008). The P1 component is typically maximal over occipital regions and has been associated with early visual processing (Salillas et al., 2008) and involuntary orienting (Fu, Caggiano, Greenwood, & Parasuraman, 2005). Studies have also shown that P1 amplitude is greater following presentation of threat compared to neutral cues, and that this effect is larger in people with trait anxiety (Li, Li, & Luo, 2005). Based on these findings, the P1 amplitude is a possible index of hypervigilance (Hofmann, Ellard, & Siegle, 2012).

Hypervigilance. In multiple ERP studies, increased P1 amplitudes have been observed following exposure to threat-related stimuli in people with anxiety. There are no known studies to investigate specific fear using the dot-probe or spatial cueing paradigm; however Venettacci (2014) used a go/nogo flanker task to investigate hypervigilance in a sample with high and low fear of spiders. This task required participants to respond to a central stimulus which was either a schematic spider or flower by pressing a button when the central stimulus was green (go), but not when it was yellow (nogo). The central stimulus was either flanked by the same stimulus as

the central target (congruent), or different (incongruent). Results showed that participants with a high fear of spiders displayed significantly faster reaction times, and greater P1 amplitude, to all trials containing spider stimuli (Venettacci, 2014). Similarly, studies using the dot-probe paradigm have shown that people with social phobia display greater P1 amplitude to targets replacing angry/neutral face pairs compared to happy/neutral face pairs (Mueller et al., 2009).

Disengagement Difficulties. There is no research investigating the ERP components implicated in disengagement difficulties. Considering greater P1 amplitude has been observed for targets following valid-threatening cues as a result of rapid facilitated attentional engagement - that is, hypervigilance – perhaps targets requiring a rapid shift of attention from invalidly-cued threatening images to attend to the target would result in decreased P1 amplitude in people with a high fear of spiders due to a disruption in the shifting process because of disengagement difficulties.

Rationale and Aim

Many studies have investigated the attentional biases in specific fear and found mixed results. For example, research using the dot-probe task has found faster reaction times to probes replacing threatening spider stimuli compared to controls, however, this paradigm does not allow for the delineation of hypervigilance and disengagement difficulties. That is, the difference in responses between congruent trials, or trials with the probe appearing in the same location as the threat-related image, and incongruent trials, or trials with the probe appearing on the opposite side of the image, could be due to hypervigilance, disengagement difficulties, or both. Evidence for both hypervigilance and disengagement difficulties has been found in trait-anxious samples, however, no studies are yet to replicate this finding in specific

fear samples. Therefore it is not known whether these processes also occur in specific fear. Thus, the present study aimed to examine the attentional biases of hypervigilance and disengagement difficulties in participants with a specific fear of spiders. To disentangle the two biases, a modified spatial cueing task was used with stimulus presentations of 100ms and highly arousing spider images. Further, ERPs were obtained in order to examine the brain activity underlying hypervigilance and disengagement difficulties in specific fear, a relatively novel subject in the field.

Hypotheses

Consistent with the commonly found validity effect displayed in anxiety in spatial cueing research, an interaction was hypothesised for behavioural data such that compared to controls, participants with a high fear of spiders would display faster reaction times to targets preceded by a valid-spider cue as a result of hypervigilance, and slower reaction times to targets preceded by an invalid-spider cue due to disengagement difficulties Reaction times to targets following neutral (cow) cues would be similar to the low fear group. In terms of electrophysiological responses, it was hypothesised that high fear participants would display hypervigilance as indexed by an increased P1 amplitude compared to low fear controls on valid trials cued by spider images. Finally, invalid targets requiring disengagement from the cue would result in significantly decreased amplitude of the P1 component in high fear compared to low fear controls on trials cued by spider images.

Method

Participants

Participants were 32 females (17 high fear) aged 18-30 years (*M*=21.35, *SD*=3.38), 28 of which were psychology undergraduates receiving course credit to

participate, the remainder were volunteers known to the experimenters. Nine participants were excluded from analysis, four due to extreme outlying mean reaction times, three participants due to accuracy less than 70%, and two participants who had conflicting scores on the spider fear scales (such that one scale indicated high fear and the other indicated low fear). The final sample comprised 13 high fear participants and 10 low fear participants.

Participants were recruited by means of posters displayed throughout the University of Tasmania and through the Division of Psychology research participation internet site. Participation in the study was based on scores from the Spider Phobia Questionnaire (Watts & Sharrock, 1984) with a median split (median value = 10) determining which group participants were placed in. All participants were given an information sheet and provided informed consent prior to participation.

Participants were excluded if they had a history of medical, neurological, or mental disorders (other than anxiety and affective disorders), were users of illicit drugs within the last month, or more than ten times during their lifetime, users of psychoactive medications, and tobacco, were problem drinkers (evident in a score higher than 16 on the AUDIT; Babor, Higgins-Biddle, Saunders, & Monteiro, 2001), were psychologically distressed (evident in a score higher than 30 on the K10; Kessler et al., 2002), or were pregnant.

Materials and Apparatus

Questionnaire Measures. The Spider Phobia Questionnaire (SPQ; Watts & Sharrock, 1984) was used to screen phobia of spiders. The SPQ consists of 33 yes/no questions regarding responsiveness to spiders (e.g., "*Do you check the lounge for spiders before sitting down?*"). The questions measure dimensions of vigilance,

preoccupation and coping/avoidance in relation to spiders. Response bias is avoided through use of reversed scoring for five of the items. The SPQ has good internal consistency (Cronbach's alpha = 0.91) and test-retest reliability (*r* =.94) (Watts & Sharrock, 1984).

The Fear of Spiders Questionnaire (FSQ; Szymanski & O'Donohue, 1995) was used as a secondary measure of spider fear. The FSQ is a good measure of spider fear within low fear populations as its items are based on a restricted time period (Muris & Merckelbach, 1996). The FSQ is an 18-item questionnaire measuring responsiveness to spiders with questions (e.g., "*If I saw a spider now, I would think it will harm me*"). Answers are provided on a scale from 1(definitely not) to 7 (definitely) with higher scores indicating increased intensity of spider phobia symptoms. The FSQ has good internal consistency (Cronbach's alpha = 0.97) and good test-retest reliability (*r*=0.94; Muris & Merckelbach, 1996).

The Kessler Psychological Distress scale (K10; Kessler et al., 2002) is a 10-item scale measuring psychological distress on a six point Likert scale from 1 (none of the time) to 6 (none of the time). Participants answer a series of questions regarding their experience of psychological distress within the last four weeks (e.g., "*Did you feel so nervous that nothing could calm you down"*). Scores range from a minimum of 10 to a maximum of 40 and participants were excluded if they reached a score of at least 30 which indicates a high risk of psychological distress. The K10 has good internal consistency (Cronbach's alpha = 0.93) (Kessler et al., 2002).

The State-Trait Anxiety Inventory Form Y-2 (STAI; Speilberger, 1983) is a 20-item scale which was used to assess trait anxiety. Answers are rated on a 4-point Likert scale (from "almost never" to "almost always"), with higher scores indicating higher trait anxiety. Items (e.g., "*I lack self-confidence")* measure worry, stress and

discomfort (Speilberger et al., 1983). The STAI has good internal consistency (Cronbach's alpha = 0.90) and test-retest reliability for males (*r*=.68) and females (*r*=.65) (Speilberger et al., 1983).

The Weschler Test of Adult Reading (WTAR) is a test used to measure intellectual functioning (Wechsler, 2001). It consists of 50 irregularly spelled words which the participant is asked to pronounce correctly. Each correctly pronounced word gives a score of one, and the test is ended once the participant incorrectly answers 12 words incorrectly. The test has strong concurrent validity with scores correlating highly with measures of verbal comprehension (*r* = .74), verbal IQ (*r* = .75), and full-scale IQ (*r*=.73; Wechsler, 2001).

The Alcohol Use Disorders Identification Test (AUDIT; Babor et al., 2001) was used to screen for problematic alcohol consumption. The AUDIT is a 10-item screening test designed to measure alcohol consumption, alcohol dependence, and alcohol related problems across gender, age, and cultures. Two drinking frequency questions (e.g., "*How many standard drinks do you have on a typical day when you are drinking?*") are rated on a 5-point scale from '1 or two' to '10 or more'. Six drinking frequency questions (e.g., "*How often do you have six or more standard drinks on one occasion?*") are rated on a five-point scale from 'Never' to 'Daily or almost daily'. Two drinking severity questions (e.g., "*Have you or someone else been injured because of your drinking?*") are rated on a three-point scale from 'No' to 'Yes, during the last year'. A score of 16 and above indicates potential dependence on alcohol (Babor et al., 2001).

A Video Gaming Experience Questionnaire (VGEQ) was custom made for the current study. The VGEQ comprised of one question asking participants how often they play video games. Participants answered either, never play video games,

rarely play video games (less than 2 hours a month), occasionally play video games (between 30 minutes and 2 hours a week), regularly play video games (between 2 hours and 5 hours a week), or often play video games (more than 5 hours a week). This questionnaire does not have tested psychometric properties, but was administered in an attempt to test for potential confounds. For example, research suggests that video games improve visual attention, such that top-down processing is improved, resulting in enhanced goal focussed attention (Hubert-Wallander, Green, & Bavelier, 2011).

The Spatial Cueing Paradigm. The spatial cueing task was presented using NeuroScan STIM 3.1 software. At the beginning of the task, instructions were shown on the computer screen. Prior to the true experimental trials, 10 practice trials were presented. The test phase consisted of 128 trials presented in random order. Every trial included a white fixation cross presented in the middle of the screen for 500ms. Following the fixation cross, a pictorial cue (5.5 x 8cm) appeared for 100ms in either the left or right visual field, with the edge of the picture 1cm from the fixation cross. The pictorial cue was either a spider (threat-related) or a cow (neutral) image. These images had a creative commons license and were sourced from Flickr, a photo sharing website. Cues were either valid or invalid; that is, they either correctly or incorrectly indicated the location of the target. The target was validly cued on 50% of trials. Almost immediately (~12ms) after cue offset, a target was presented. The target was a white dot, measuring at 1cm in diameter, which remained on screen for 2000ms or until a response was made. Left or right index finger responses were made via button press on a NeuroScan response pad for left and right visual field targets respectively. The next trial began immediately after a response was made.

Electrophysiological (EEG) recording. The EEG recording was obtained by means of the NeuroSCAN system (Scan 4.4 system) and 32-channel Quik-Cap with Ag/AgCl sintered electrodes. Using the international 10-20 system of electrode placement, continuous EEG data was recorded from 32 sites. Data was sampled continuously at a rate of 1000Hz. Electrode impedance was kept below 10kΩ. Electrodes were referenced to linked mastoids and also placed on the outer canthi of both eyes and the upper and lower left eye to measure horizontal and vertical electro-oculographic (EOG) activity.

In the editing phase, behavioural data was merged with continuous EEG data and then data was filtered using a Zero-phase-shift low pass filter (30Hz, 24 dB/Oct). Ocular artefact rejection was then undertaken to minimise the impact of eye blinks on the other electrode channels. Following this, epochs were extracted from the data from 200ms before stimulus onset to 900ms post stimulus. Subsequent artefact rejection and baseline correction was conducted with trials containing artefacts above 70 μV and below -70 μV rejected. The occipital P1 component was determined from grand averaged waveforms for each condition and was defined as the maximum amplitude between 80-120ms post target onsets.

Procedure

Ethics Approval was gained through the University of Tasmania Human Research Ethics Committee (see Appendix A) and each participant provided written informed consent (see Appendix B). Prior to the experimental session, participants were screened via an online survey to determine their demographics, fear of spiders, alcohol use, and psychological distress, and participants meeting inclusion criteria were invited to participate. Each participant completed a two hour experimental session. Upon arrival, participants completed a list of forms detailing their caffeine

intake, medication, the Karolinska Sleepiness Scale (Åkerstedt & Gillberg, 1990) (see Appendix C), computer game usage (see Appendix D), menstrual cycle (see Appendix E), the STAI (Speilberger, 1983) and the WTAR (Wechsler, 2001). Participants were set up for the EEG recording and placed in front of a computer 50 cm away from the screen. Participants completed the customised spatial cueing task. Following the completion of the spatial cueing task, participants were asked to rate the pictures presented in the task for valence (1=highly unpleasant to 9=highly pleasant) and arousal (1=low arousal to 9=highly arousing). To conclude the session, the participants were debriefed.

Design and Data Analysis

Data was assessed to ensure the assumptions of ANOVA were met. Mean valence and arousal ratings were analysed using two separate 2 (Group: high fear/low fear) x 2 (Image: spider/cow) mixed measures ANOVAs with Group as the between subjects factor, Image as the within-subjects factor. Mean reaction time was the dependent variable for the behavioural measures of hypervigilance and disengagement difficulties. For analysis of mean RT (ms) and accuracy (percentage of correct trials) to target stimuli, a 2 (Group: high fear/low fear) x2 (Validity: valid/invalid) x2 (Image: spider/cow) mixed measures ANOVA was used, with Group as a between subjects factor and Validity and Image as within subjects factors.

The electrophysiological dependent variable used to measure hypervigilance and disengagement difficulties was peak amplitude of the P1 ERP component. P1 amplitude was analysed at the midline occipital site (Oz). For analysis of P1 amplitude, a 2 (Group: high fear/low fear) x2 (Validity: valid/invalid) x2 (Image: spider/cow) mixed measures ANOVA was conducted, with Group as a between subjects factor and Validity and Image as within subjects factors. Significant

interactions were further analysed by examination of simple main effects with Bonferroni corrections to hold the type I error rate to less than 5% following multiple tests. Effects sizes were clarified with partial eta square for omnibus ANOVAs and Cohen's *d* (Cohen, 1992) for tests of simple effects. Cohen's guidelines for interpretation were used (0.2=small, 0.5=medium, 0.8=large).

Results

Demographics

Table 1 shows the mean age and mean raw scores on questionnaire measures for each group. There were no significant differences between the groups on age, trait anxiety (STAI), verbal intelligence (WTAR), psychological distress (K10), alcohol dependence (AUDIT) and sleepiness (Karolinska). As expected, there was a significant difference in spider fear between the groups such that the high fear group scored higher on measures of spider fear. For psychological distress (K10 scores) there was a trend towards significance such that the low fear group scored higher than the high fear group.

Table 1

Mean Age and Raw Scores on Measures of Spider Fear, Anxiety, Reading Ability, Video Game Usage, and Alertness for High and Low Spider Fear Groups

	Low Fear *M*(*SD*)	High Fear *M*(*SD*)	*F*(1,21)	*p*	Cohen's *d*
Age	20.8 (2.15)	21.8 (4.13)	0.5	0.5	0.3
$SPQ_{/33}$	4.5 (1.27)	16.9 (4.43)	73.4	<.001	3.6
$FSQ_{/126}$	28.7 (9.63)	94.4 (17.64)	112.1	<.001	.05
STAI	34.3 (5.08)	33.8 (8.53)	0.03	0.9	0.1
WTAR	35.8 (7.29)	37.5 (6.03)	0.1	0.5	0.3
K10	16.9 (4.53)	13.9 (3.62)	3.1	0.1	0.7
AUDIT	5.7 (2.56)	4.6 (2.87)	0.9	0.4	0.2
VGEQ	4.2 (1.29)	3.7(1.36)	0.01	0.5	0.3
Karolinska	4.2 (1.29)	3.7 (1.36)	0.6	0.5	0.3

Valence and arousal ratings

Table 2 shows the mean valence and arousal ratings for spider and cow images. Analysis of valence ratings revealed a significant main effect of Image such that both groups rated the spider images (*M*=3.34, *SD*=1.0) significantly less pleasant than the cow images (*M*=5.55, *SD*=.92), *F*(1,17)=42.80, *p*<.001, η_p^2=.72. There was a non-significant main effect of Group, *F*(1,17)=4.38, *p*=.052, η_p^2=.21, however there was a trend for significance such that the high fear group rated images to be less pleasant (*M*=4.16, *SD*=.58) than the low fear group (*M*=4.73, *SD*=.58). This trend was modified by a significant Group x Image interaction, *F*(1,17)=10.75, *p*=.004, η_p^2=.39. Tests of simple effects revealed that while both groups rated the spider

images as more negative than the cow images, the high fear group rated the spiders as significantly more unpleasant than the low fear group, $F(1,17)=12.52$, $p=.002$, $d=1.74$, whereas ratings for the cows for the high fear group and the low fear group were not significantly different $F(1,17)=1.68$, $p=.212$, $d=.61$. Analysis of Arousal ratings revealed no significant difference in ratings as there was a non-significant main effects of Group, $F(1,17)=2.36$, $p=.143$, $\eta_p^2=.122$, and Image, $F(1,17)=3.92$, $p=.064$, $\eta_p^2=.188$, and a non-significant interaction between Group and Image, $F(1,17)=.771$, $p=.392$, $\eta_p^2=.043$.

Table 2

Mean Valence and Arousal Ratings for Spider and Cow Images Used as Cues in the Task

	Valence		Arousal	
	Spider	Cow	Spider	Cow
Low Fear	4.18 (0.96)	5.29 (0.87)	3.34 (1.82)	1.87 (1.40)
High Fear	2.50 (0.96)	5.82 (0.87)	3.77 (1.82)	3.20 (1.40)

Note. Standard deviations are presented in parentheses.

Accuracy

Table 3 shows the mean accuracy of responses to targets following spider and cow cues during valid and invalid presentations. Analysis of accuracy (percentage of correct trials) showed a significant main effect of Image, $F(1, 21)=4.50$, $p=.05$, $\eta_p^2=.18$, whereby participants were significantly less accurate when the cue was a

spider (*M*=97.4, *SD*=3.1), compared to when the cue was a cow (*M*=98.3, *SD*=2.3). Neither the Group, $F(1,21)=.16$, $p=.70$, $\eta_p^2=.01$, nor Validity, $F(1,21)=2.20$, $p=.15$, $\eta_p^2=.10$, main effects were significant. The Group x Validity interaction, $F(1,21)=.12$, $p=.73$, $\eta_p^2=.01$, and the Group x Image interaction, $F(1,21)=.89$, $p=.36$, $\eta_p^2=.04$, were non-significant. There was, however, a significant Validity x Image interaction $F(1,21)=5.12$, $p=.03$, $\eta_p^2=.20$. Bonferroni corrected ($\alpha=.025$) tests of simple main effects of Image at each level of Validity revealed that there was no differences in accuracy between spider (*M*=99.0, *SD*=1.9) and cow cues (*M*=98.1, *SD*=3.7) on valid trials ($p=.243$, $d=.31$). For invalid trials, responses were significantly less accurate following the spider (*M*=95.8, *SD*=6.3) compared to the cow (*M*=98.6, *SD*=2.7) cues ($p=.014$, $d=.58$).

Table 3

Mean Accuracy of Responses to Targets Following Spider and Cow Cues in Valid and Invalid Trials for High and Low Spider Fear Groups

	Spider		Cow	
	Valid	Invalid	Valid	Invalid
Low Fear	99.3 (2.8)	94.7 (9.4)	97.7 (5.6)	99.0 (4.0)
High Fear	98.7 (2.5)	96.9 (8.3)	98.5 (4.9)	98.2 (3.5)

Note. Means are presented as percentages. Standard deviations are presented in parentheses.

Reaction Time

Table 4 shows the mean reaction times to targets following spider and cow cues during valid and invalid presentations. There was a significant main effect of Group, $F(1,21)=4.65$, $p=.04$, $\eta_p^2=.18$, showing that the reaction times for the high fear group were significantly slower ($M=331.3$, $SD=52.8$) than reaction times for the low fear group ($M=295.3$, $SD=60.1$). The main effect of Validity was non-significant, $F(1,21)=2.87$, $p=.11$, $\eta_p^2=.12$, showing that reaction times to valid cues ($M=307.9$, $SD=40.0$) were not significantly different to reaction times to invalid cues ($M=318.7$, $SD=45.5$). The main effect of Image was significant, $F(1,21)=5.99$, $p=.02$, $\eta_p^2=.22$, demonstrating that reaction times on trials cued by spider images were significantly faster ($M=311.2$, $SD=39.4$) than reaction times to cow images ($M=315.4$, $SD=41.0$). The Group x Validity interaction was non-significant, $F(1,21)=.26$, $p=.61$, $\eta_p^2=.01$, as was the Group x Image interaction, $F(1,21)<.001$, $p=.99$, $\eta_p^2<.001$, and the Validity x Image interaction, $F(1,21)=1.29$, $p=.27$, $\eta_p^2=.06$. The Group x Validity x Image interaction was non-significant, $F(1,21)=.05$, $p=.83$, $\eta_p^2=.002$.

Table 4

Mean Reaction Time for Targets Following Spider and Cow Cues in Valid and Invalid Trials for High and Low Spider Fear Groups

	Spider		Cow	
	Valid	Invalid	Valid	Invalid
Low Fear	285.3 (59.7)	301.1 (70.1)	291.2 (62.1)	303.6 (67.7)
High Fear	324.2 (52.3)	334.2 (61.5)	330.9 (54.5)	335.9 (59.4)

Note. Standard deviations are presented in parentheses.

Peak P1 Amplitude

Table 4 shows the mean peak P1 amplitude to targets following spider and cow cues in valid and invalid trials for high and low fear groups. Figures 1 and 2 show grand mean average wave forms at the midline occipital site (Oz) for low and high fear participants respectively. Figure 1 shows peak P1 amplitude (peaking at approx. 100ms) for low fear participants differed as a function of cue type such that targets following spider cues produced significantly greater P1 amplitude than targets following cow cues. Figure 2 demonstrates a similar peak P1 amplitude for the high fear group following the exposure to threat-related and neutral targets.

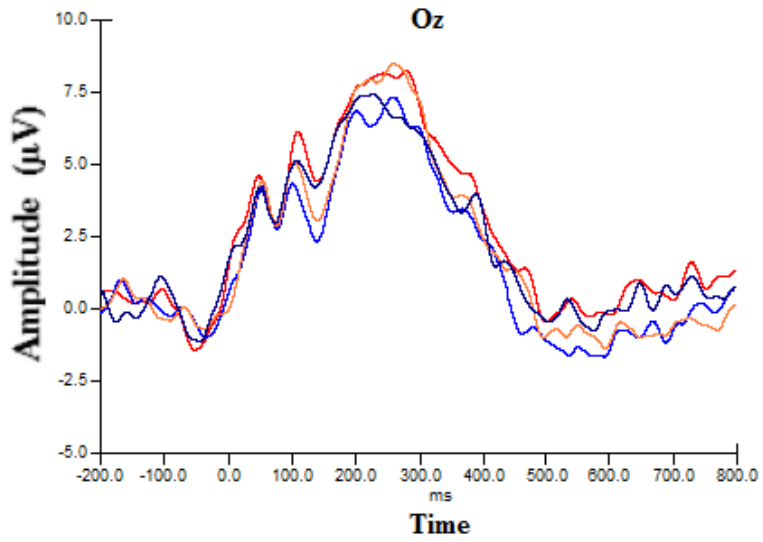

Figure 1. Grand averaged waveforms for low fear participants at the midline occipital site (Oz) for valid and invalid threat-relevant and neutral cues.

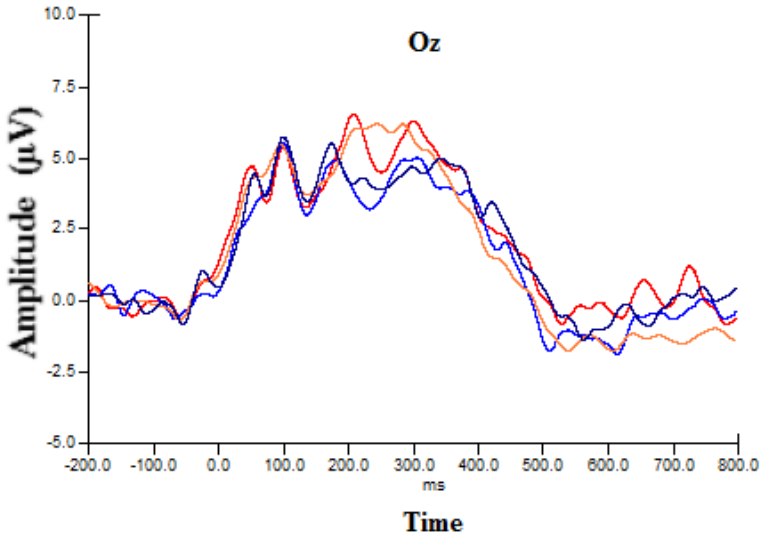

Figure 2. Grand averaged waveforms for high fear participants at the midline occipital site (Oz) for valid and invalid threat-relevant and neutral cues.

The main effects of Group, $F(1,21)=1.26$, $p=.28$, $\eta_p^2=.06$, Validity $F(1,21)=.39$, $p=.54$, $\eta_p^2=.02$, and Image, $F(1,21)=2.57$, $p=.12$, $\eta_p^2=.11$, were all non-significant. The Group x Validity, $F(1,21)=.57$, $p=.46$, $\eta_p^2=.10$, and the Validity x Image, $F(1,21)=.06$, $p=.81$, $\eta_p^2=.003$, interactions were non-significant. A significant Group x Image interaction was revealed, $F(1,21)=13.66$, $p=.001$, $\eta_p^2=.39$. Bonferroni corrected ($\alpha=.025$) tests of simple main effects of Image were conducted for each group. As can be seen in Figure 3, the low fear group showed significantly greater P1 amplitude to targets following the spider image ($M=6.15$, $SD=3.36$) compared to the cow image ($M=4.59$, $SD=3.19$), $F(1,9)=12.36$, $p=.01$, $d=0.48$. The high fear group did not show a significant difference in P1 amplitude between the spider ($M=6.48$, $SD=3.29$) and cow images ($M=7.09$, $SD=3.14$), $F(1,12)=2.53$, $p=.14$, $d=0.19$. Between the groups, P1 amplitude did not differ significantly for targets following spider images, $F(1,21)=.06$, $p=.81$, $d=.10$, or the cow images, $F(1,21)=3.93$, $p=.06$, $d=.83$, however there was a trend for significance such that high fear group displayed greater P1 amplitude to targets following cow images ($M=7.09$, $SD=3.00$) relative to the low fear group ($M=4.59$, $SD=3.00$). The Group x Validity x Image interaction was non-significant, $F(1,21)=.01$, $p=.92$, $\eta_p^2=.001$.

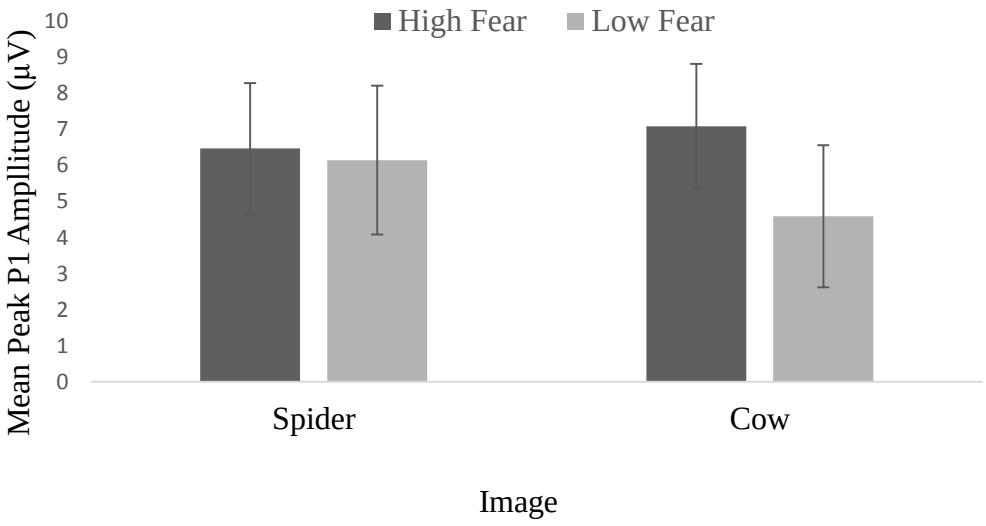

Figure 3. Mean peak P1 amplitude for targets following spider and cow cues in low and high fear participants (error bars represent 95% CIs).

Table 5

Mean Peak P1 Amplitude to Targets Following Spider and Cow Cues in Valid and Invalid Trials for High and Low Spider Fear Groups

	Spider		Cow	
	Valid	Invalid	Valid	Invalid
Low Fear	5.8 (3.5)	6.5 (3.6)	4.2 (3.4)	5.0 (3.3)
High Fear	6.6 (3.5)	6.4 (3.6)	7.1 (3.4)	7.1 (3.3)

Note. Means are presented as percentages. Standard deviations are presented in parentheses.

Discussion

The aim of the present study was to investigate hypervigilance and disengagement difficulty biases in people with a high fear of spiders. The hypothesis that relative to low fear controls, participants with a high fear of spiders would display faster reaction times to targets preceded by a valid-spider cue as a result of hypervigilance, and slower reaction times to targets preceded by an invalid-spider cue as a result of difficulty disengaging was not supported as the Group x Validity x Image interaction was non-significant. In fact, high fear participants were slower to react to all targets relative to the low fear controls regardless of whether the cue was valid or invalid or a spider or cow. Also unexpectedly, both the high fear group and the low fear controls displayed significantly faster reaction times to targets preceded by spider images relative to cow images.

The hypotheses that high fear participants would display greater P1 amplitude to targets following valid spider cues as evidence of hypervigilance and lower P1 amplitude to targets following invalid spider cues as evidence of disengagement difficulties were not supported. Unexpectedly, the low fear group displayed significantly greater P1 amplitude for targets cued by spiders compared to cows, whereas the high fear group showed no difference in peak P1 amplitude to targets following spider or cow cues.

Analysis of accuracy found no differences between the high fear and low fear groups for accuracy in responses. This shows a speed-accuracy trade off does not account for the group differences in reaction time. Results also showed that people were more accurate following cow cues compared to spider cues. An Image x Validity interaction showed that accuracy was greater following cow cues compared to spider cues in invalid trials, but this was not shown for valid trials.

For valence ratings, the two groups rated the cows similarly; however the high fear group rated the spiders as significantly more unpleasant than the low fear group. This suggests a greater dislike for spiders in the high fear group relative to the low fear group. Results showed that there was no difference between the groups for arousal ratings. This could be a result of participants not understanding exactly what they were rating. Participants were told to rate the images based on the physiological arousal they induce. Perhaps if they were told specific feelings such as increased heart rate and sweating there may have been more objective ratings which may have shown a difference.

Reaction Times

Overall greater reaction times were found for the high fear group compared to the low fear group. This does not support hypervigilance as valid-spider cues did not facilitate the processing of the following targets. It also does not fully support disengagement difficulties as greater reaction times were found not only following invalid-spider cues, but all cues, relative to low fear controls. Previous research implementing the spatial cueing task has found evidence to support hypervigilance and disengagement difficulties through faster reaction times to valid-spider cues and greater reaction times to invalid-spider cues, however this was in a high trait-anxious sample (Koster et al., 2006).

Trait anxiety differs to specific fear in a few key ways. Specific fear is an excessive, irrational fear of a particular situation or object (Choy, Fyer, & Lipsitz, 2007) resulting in transient feelings of tension, apprehension, decreased attentional control and increased autonomic arousal (Ravindranadan & Thomas, 2011). While trait anxiety can also induce feelings of tension, apprehension, decreased attentional control and increased autonomic arousal, these are not transient, but rather stable

characteristics of personality which are displayed across a number of situations. Therefore, it is possible that trait anxiety and specific phobia are not directly comparable. Specific phobia is more closely related to state anxiety which is a transitory emotional state which varies in intensity depending on the situation (Ravindranadan & Thomas, 2011). According to Pacheco-Unguetti, Acostaa Marqués, and Lupiánez (2011), trait-anxious individuals display constant attention to threat, and thus, tend to display facilitated attention towards, and difficulty disengaging from, threat. In contrast, state anxious individuals place increased threat value on stimuli associated with a fearful situation, and thus are thought to display an overall increased stimulus-driven attentional processing in fearful situations (Pacheco-Unguetti et al., 2011). Mathews and Mackintosh (1998) also describe a decreased threshold for appraising a stimulus as threatening in people who are experiencing state anxiety. Considering the similarities between state anxiety and specific fear, the idea of an increased bottom-up processing of all environmental stimuli and a decreased threshold for threat-appraisal in people with state anxiety may apply to the present study; however this must be approached with caution. While high trait-anxious participants completing an emotional spatial cueing task display faster reaction times to valid-spider cues and greater reaction times to invalid-spider cues, state anxious, and thus perhaps specific fearful, individuals demonstrate a decreased threshold for appraising stimuli presented in the task as threatening which leads to an increased bottom-up processing, ultimately resulting in stimulus-driven cue stimuli being a distraction from the goal of reacting to the target. Evidence from other studies in spider fear has found evidence in support of this.

Although not using cueing tasks, an overall increase in reaction times has been observed in studies that require participants with spider fear to ignore task

irrelevant spider distractors. For example, research has found that people with a high fear of spiders had greater colour naming latencies in the original Stroop task when there was a spider in the same room as them compared to when there was no spider (Kwakkenbos, Becker, & Rinck, 2010). Slowed colour naming in the spider-related Stroop paradigms has been attributed to a prioritised attentional processing of threat-related information which interferes with the goal of naming the colour (Williams et al., 1996). Kindt and Brosschot (1997) also found that people with a phobia of spiders displayed greater reaction times to spider-related stimuli in pictorial and linguistic Stroop tasks, and this was found despite the fact that participants rated the pictures as more aversive than the words. This suggests that when faced with threatening stimuli, people with a phobia of spiders attend to, and process, stimuli in the environment in a general and automatic manner regardless of either its goal-relevance or its threat-value as a result of increased bottom-up processing. This may explain the current study's finding of similar reaction times to all targets regardless of Validity or Image; perhaps being presented with a spider stimulus resulted in the inability to inhibit automatic and general bottom-up processing of all cues in the task regardless of goal-relevance and threat-value, resulting in interference from the goal of quickly reacting to the target.

The slowed reaction times to the target observed in the high fear group are suggestive of a disruption of Petersen and Posner's (2012) executive network. The executive network involves brain regions such as the anterior cingulate cortex and the prefrontal cortex. The executive network is a voluntary control system that is involved in top-down regulation of attention; particularly, regulating the balance between stimulus-driven and goal-driven attention. The balance between orienting and executive attention depends on attentional control such that people with greater

attentional control have a greater influence over voluntary attention which can override irrelevant stimulus-driven attention (Derryberry & Reed, 2002; Eysenck et al., 2007). Inhibition and shifting are two particular functions of the executive network which are vital during attentional control; (Miyake et al., 2000). Inhibition refers to the ability to suppress automatic or prepotent responses that are task-irrelevant, whereas shifting refers to the strategic shifting of attention between tasks (Miyake et al., 2000). According to the attentional control theory, the ability to inhibit task-irrelevant stimuli is essential to avoid interference from distracting stimuli (Eysenck et al., 2007).

Consistent with attentional control theory (Eysenck et al., 2007), the present results are suggestive of an increased influence of stimulus-driven attentional processing and a decreased influence of goal-driven processing, such that the ventral fronto-parietal network may have overridden the dorsal fronto-parietal network's goal-directed attention when stimuli perceived as threatening were detected in the environment (Corbetta & Shulman, 2002). Considering that the reaction times of the high fear group were longer, even for the valid trials, the current results are indicative of a deficit in executive functioning. It is possible that the high fear group were not able to regulate the automatic processing of cues, which ultimately resulted in interference of goal-relevant processing.

Although not displayed through greater reaction times to invalid-spider cues relative to low fear controls, disengagement difficulties may still be evident in the present findings. Matlow, Gard and Berg (2012) suggest that rather than impairment in the shifting of attention to task-relevant stimuli, the mechanisms underlying delayed disengaging are impairment in responding as a result of interference; that is, participants with anxiety have trouble disengaging attention from threat which is

manifested as an interference in response execution. Using a dot-probe task with threatening, positive and neutral images, Matlow et al. found that high trait-anxious individuals had greater reaction times to trials in which the probe appeared on the opposite side of the threatening image, relative to trials in which probes appear in the same location as the threatening image, and trials in which there are no threatening images. This was interpreted as showing disengagement difficulties. To further understand the mechanisms that underlie disengagement difficulties, results from an electrooculogram recording did not show a slowed shifting of visual attention away from the threatening images to the goal-relevant target. From this, Matlow et al. interpreted the results as being a deficit of the executive network resulting from enhanced attentional engagement towards, and mental processing of, the threatening stimulus which ultimately led to subsequent delays in the decision making and response execution processes of the executive system.

If delayed disengagement is demonstrated through interference, then it could be argued that the results of the current study do support delayed disengaging. This would be consistent with the attention maintenance theory. That is, the results demonstrate a possible slowed disengagement from threat such that an increased dwell time on threatening stimuli can result in the inability to inhibit the processing of threatening distractors (Fox et al., 2001). Of course, this must be interpreted with caution as specific fear differs from trait anxiety. No solid conclusion can be made until these findings are replicated in participants with specific fear.

In contrast, Mogg, Holmes, Garner, and Bradley (2008) suggest that hypervigilance and disengagement difficulties are two separate processes from interference. Mogg et al. claim that the spatial cueing task and the dot-probe task do not provide a distinction between slowed reaction times due to interference from the

threat as seems apparent in the present study, and the hypothesised effects of threat-related attentional cueing, that is, slowed responses to invalid-spider cues and faster responses to valid-spider cues. Mogg et al. found increased reaction times to invalid-spider cues but similar responses to valid-spider cues in a high anxious sample relative to low anxious participants. However, once determining how much of the reaction times were due to interference-related response slowing by subtracting differences in results in an endogenous cueing task (a task with a single threat image presented in the middle of the screen, so that shifting of attention could account for the results) from results in an exogenous cueing task (with cues either side of the fixation, similar to the present study), they found that high anxious participants showed faster reaction times on valid-threat trials and not invalid-threat trials (Mogg et al., 2008). It was suggested that response slowing could also be due to a freezing response in the presence of fear.

These results could relate to the present study to explain the failure to find hypervigilance and disengagement difficulties in behavioural data. Perhaps the requirement to produce an overt response to the target required a decision making process which measured executive function rather than automatic, involuntary, bottom-up attentional biases (Matlow et al., 2012). Based on this this response slowing tendency evidenced in the spatial cueing task, future research should look into paradigms which assess hypervigilance and disengagement difficulties without the possibility of response slowing.

P1 Component

The finding of greater P1 amplitude for the high fear group for all targets is not concordant with previous research that has found that people with a high fear of spiders display greater P1 amplitude to threatening relative to neutral trials

(Venettacci, 2014). Other researchers have found a general increase of the P1 component to spider as well as neutral stimuli. For example, in a colour and object identification task requiring participants to discriminate between, or identify the colour of, spider and flower stimuli, Kolassa et al. (2006) found greater P1 amplitude for the identification of both spiders and flowers in participants with a high fear of spiders relative to controls. Similarly, Michalowski et al. (2009) found that high fear participants had greater P1 amplitudes for both phobia-relevant, as well as standard threatening, positive and neutral images, in a passive picture-viewing task when compared to low-fear controls. Considering that the P1 component is modulated by attention, and is thought to reflect involuntary orienting and enhanced early visual processing (Fu et al., 2005; Hillyard et al., 1994), the finding of increased P1 amplitude for both spider and cow cues is suggestive of a general hypervigilance to all environmental stimuli, such that attention was automatically oriented to all cues in the task during early visual processing. Although it was predicted that P1 amplitude following cow cues would be similar for the high fear group compared to the low fear group, there was a trend for significance with a strong effect size ($p=.06$, $d=.83$) suggesting that the high fear group displayed higher P1 amplitude following cow cues than the low fear group. Considering the sample size was relatively small, this may be a lack of power. Taken together, the between groups and within groups results may suggest that the high fear group displayed increased P1 for all cues relative to controls who only showed increased P1 to spiders which reinforces the idea of general hypervigilance.

Future research could investigate the P1 component in a spider fearful sample to observe whether increased P1 amplitude is displayed when there are no spiders in the task. This would provide insight into whether the observed threat in the current

study resulted in the participants displaying a general hypervigilance, or whether they always display general hypervigilance regardless of perceived threat. If specific fear is similar to state anxiety, they should display a general hypervigilance, indexed by increased P1, only in the presence of fearful stimuli.

Although expected for the high fear group, greater occipital P1 amplitude for valid-spider cued targets compared to cow cued targets was observed in the low fear group. Additionally, between groups analysis showed that the low fear group did not significantly differ from the high fear group in P1 amplitude to targets following spider cues. This may suggest that enhanced early orienting processes for spider targets were demonstrated by both groups. An increased P1 amplitude observed in the control group could be indexing enhanced visual processing of potentially dangerous stimuli. Enhanced visual processing of danger is consistent with the threat-superiority effect which refers to the way in which attention is captured more easily by stimuli that are associated with fear or danger compared to non-threatening stimuli (Öhman et al., 2001). Enhanced attentional processing of threat-related stimuli is thought to be an evolutionary process that is associated with a greater chance of survival (Brown, El-Deredy, & Blanchette, 2010). Öhman et al. (2001) proposed a neural circuitry referred to as the 'fear module' that constantly scans the environment for potential dangers that require a fast and automatic response. This theory posits that this effect occurs for any stimuli, including spiders, which would have been potentially dangerous in the time of the fear module's evolution (Brown et al., 2010).

Behavioural evidence has shown that evolutionarily-relevant spider stimuli guide attentional processes in healthy participants. Using a visual search task, Blanchette (2006) and Öhman et al. (2001) found that participants were faster to

determine whether an evolutionarily threatening target stimulus was in the same category, or a discrepant category, from a grid of threat or neutral-stimuli. There is no research into the occipital P1 ERP indexing early enhanced visual processing in evolutionarily-relevant spider stimuli. However, there is evidence that evolutionarily-relevant facial expressions presented in a dot-probe task are associated with an enhanced P1 component in healthy participants (Schuller & Rossion, 2004).

ERP results did not show evidence of disengagement difficulties as the Group x Validity x Image interaction for P1 amplitude was non-significant. There was no evidence for decreased P1 amplitude for the high fear group for invalid trials, or any trials for that matter. There have been no previous studies to determine the underlying ERP correlates of disengagement difficulties. It is possible that this was not observed in the current study because the P1 component is not modulated by disengagement difficulties. Finally, the ERPs were-time locked to the target. The P1 may have indexed orienting to the target rather than the cue. Different peaks may have been observed had the ERPs been time-locked to the threatening cue. Delayed disengagement is also more evident in participants with low-attentional control. Peers and Lawrence (2009) conducted a rapid serial visual presentation task, which required them to watch a series of emotional images presented one-by-one whilst looking out for a target and reacting to it as fast as possible. They found that participants with high self-reported anxiety demonstrated greater difficulty with disengaging attention from previous threatening distractor images to respond to the target image if they had self-reported poor attentional control whereas those with high anxiety who had good attentional control did not demonstrate difficulty in disengaging attention. Considering the participants in the current study were not asked to report on their perceived attentional control, there may have been an

imbalance between the groups on ability to regulate attention. Thus disengagement difficulties in people with a fear of spiders may have been masked by good attentional control in the high fear group compared to the low fear group (Cisler & Koster, 2010). Further research should include a measure of perceived behavioural such as the Attentional Control Scale (Ólafsson et al., 2011) to balance this between the groups.

Limitations

There were limitations in the sample used in the current study. For example, there were only 23 participants which were split into high and low fear based on a median split. Thus it is possible that there was not enough difference in spider fear between the groups to observe the true effect of high spider fear. A more effective way of analysing differences would be to have a much larger screening sample and take the top 10% and the bottom 10% in terms of spider fear scores for the high and low groups respectively (Koster et al., 2006). Further, compared to previous research this study is relatively underpowered and stronger effects may be found with more participants. Additionally, the sample in the current study was non-clinical and results must be interpreted with caution when generalising to specific phobia.

Summary and Conclusions

The present study investigated behavioural and electrophysiological correlates of hypervigilance and disengagement difficulties by means of a spatial cueing paradigm. The high spider fear group displayed generally greater reaction times and similar P1 amplitude following all cues, whereas the low fear group had quicker reaction times and increased P1 amplitude to targets following spider cues. Taken together, the behavioural and ERP data provide evidence of two processes occurring throughout the task for the high fear participants. The ERP data

demonstrated early visual processing differences between the high and low fear groups that were not evident in overt responses (Luck, 1995), whereas the behavioural data demonstrated later, higher-order response deficits (Matlow et al., 2012). The current results were indicative of an early general hypervigilance to all incoming stimuli among high fear participants regardless of whether it was threatening or neutral. This generalised hypervigilance may have resulted in deficits in later attentional processes in the executive network such that an increased dwell time on cues resulted in interference in responses to the target, as displayed in greater reactions times elicited by the high fear group compared to the low fear group. Combined, the present study suggests an increased hypervigilance to cues has possibly resulted in deficits in inhibiting the processing of the cues to react only to the target. This finding is consistent with the attentional control theory (Eysenck et al., 2007) which posits that a lack of attentional control results in a lowered ability to complete tasks without interference from irrelevant stimuli. This is the first study to find evidence of a general hypervigilance followed by interference in a sample with specific fear. These findings are only preliminary and warrant further research to determine whether hypervigilance and disengagement difficulties are observed alongside a later interference effect. For example, paradigms that measure orienting separately from reactions to targets that require a response decision would be appropriate to analyse the orienting biases without effects of executive function. The current results yield treatment implications. For example, treatment programs should focus on decreasing general hypervigilance as well as focussing on the feared object to eliminate the interference of general, yet distracting, goal-irrelevant threats. Perhaps desensitisation for people with a fear of spiders should be paired with attentional control tasks such as mixed attention training - which involves training in

sustained attention, selective attention, task switching and inhibition (Wass, Scerif, & Johnson, 2012) - in order to learn to consciously focus attention onto goals rather than irrelevant environmental stimuli in the presence of spiders.

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Appendices

Appendix A

Ethics approval letter

Social Science Ethics Officer
Private Bag 01 Hobart
Tasmania 7001 Australia
Tel: (03) 6226 2763
Fax: (03) 6226 7148
Human.ethics@utas.edu.au

HUMAN RESEARCH ETHICS COMMITTEE (TASMANIA) NETWORK

12 March 2015

Dr Allison Matthews
Psychology
Private Bag 30

Sent via email

Dear Dr Matthews

Re: APPROVAL FOR AMENDMENT TO CURRENT PROJECT
Ethics Ref: **H0011104 - The effects of real versus hyper-real images on computer-based exposure treatment for spider phobia**

1. Removal of Honours students Rebecca Venettacci and Emma Robards.
2. Addition of Honours students Isobel Hoystead, Amber Johnstone, and Shelley Flynn.
3. Modification to the attentional tasks used in the study.
4. Addition of male participants (high and low spider fear groups).
5. Screening questionnaire will now be completed online.
6. Refinement of screening questionnaire including the addition of a trait anxiety measure, the K10, and the AUDIT.
7. Addition of a trait anxiety assessment and a test of adult reading on the day of the experimental session.

We are pleased to advise that the Chair of the Tasmania Social Sciences Human Research Ethics Committee approved the Amendment to the above project on 12/3/2015.

Yours sincerely

Katherine Shaw
Executive Officer
Tasmania Social Sciences HREC

Appendix B

Participant Information and Consent

PARTICIPANT INFORMATION SHEET

Spider Fear, Brain Activity, and Attention

Invitation

You are invited to participate in a research study into the effects of spider fear on attention during the viewing of spider images. This is an Honours study being conducted by Isabel Hoystead, Amber Johnstone, and Shelley Flynn under the supervision of Dr Allison Matthews (Chief Investigator, School of Medicine, Psychology).

1. 'What is the purpose of this study?'

The purpose is to investigate brain processes involved in attentional processing among males and females with high and low spider fear.

2. 'Why have I been invited to participate in this study?'

You are eligible to participate in this study because you have an intense fear of spiders or that you have a relatively low of fear spiders.

3. 'What does this study involve?'

This study will require you to attend one session (approximately 2 hours) at the University of Tasmania. In this session you will complete some questionnaires relating to your fear of spiders. You will then complete some computer tasks where you will respond (using a button press) to particular aspects of visual stimuli presented on a computer screen. These stimuli may include pictures, letters or objects (and may include pictures of spiders). Your brain activity will be measured while you complete these tasks.

It is important that you understand that your involvement is this study is voluntary. While we would be pleased to have you participate, we respect your right to decline. There will be no consequences to you if you decide not to participate, and this will not affect your relationship with the University. If you decide to discontinue participation at any time, you may do so without providing an explanation. All information will be treated in a confidential manner, and your name will not be used in any publication arising out of the research. All of the research will be kept in a locked cabinet in the office of Dr Allison Matthews or on a secure server at the University of Tasmania.

4. Are there any possible benefits from participation in this study?

You may or may not experience anxiety during the course of the study. However, if you do, it is hoped that you will notice a reduction in your anxiety after a certain period of time. The results of this study will provide valuable information on the attentional processes involved in spider fear and will help us to further develop an online treatment program for people with phobias.

5. Are there any possible risks from participation in this study?

If you experience anxiety during the study, this may be unpleasant and include emotions of fear and worrying thoughts, wishing to avoid the situation, physical discomforts such as palpitations, sweating and over-breathing. The researchers will provide you with information for coping with these symptoms if they unduly trouble you. However, if you find that you are becoming distressed or experience significantly elevated levels of anxiety you will be advised to receive support from a clinician or alternatively, we will arrange for you to see a counsellor at no expense to you..

There are no specific risks associated with the measurement of brain activity. However, if you have sensitive skin there is a small possibility of a slight skin reaction from electrode preparation materials. If you believe there is a chance that your skin may react you are advised to reconsider participation.

6. What if I have questions about this research?

If you would like to discuss any aspect of this study, or require further assistance with your fear of spiders after the study is completed, please feel free to contact Dr Allison Matthews on (03) 62267236, who would be happy to discuss any aspect of the research with you. Once we have analysed the information we will be putting a summary of our findings on the School of Psychology website for you to view. You are welcome to contact us at that time to discuss any issue relating to the research study.

This study has been approved by the Tasmanian Social Science Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study should contact the Executive Officer of the HREC (Tasmania) Network on (03) 6226 7479 or email human.ethics@utas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants. You will need to quote [H0011104].

Thank you for taking the time to consider this study. If you wish to take part in it, please sign the attached consent form. This information sheet is for you to keep.

CONSENT FORM
Spider Fear, Brain Activity, and Attention

1. I have read and understood the 'Information Sheet' for this project.
2. The nature and possible effects of the study have been explained to me.
3. I understand that the study involves attending one session (approx. 2 hours) at the University of Tasmania whereby I will complete some questionnaires and some computer based attention tasks. These tasks may involve responding to pictures (including spiders), letters, or objects and brain activity will be monitored throughout the process.
4. I understand that participation involves some risk of experiencing a heightened level of anxiety; however, the researcher will be present at all times, I will be given information on how to cope with anxiety, and I will be referred to a counsellor if need be. I understand that measurement of brain activity involves minimal risk, and slight skin irritation may occur if I have sensitive skin.
5. I understand that all research data will be securely stored on the University of Tasmania premises for ten years and will then be destroyed.
6. Any questions that I have asked have been answered to my satisfaction.
7. I agree that research data gathered from me for the study may be published provided that I cannot be identified as a participant.
8. I understand that the researchers will maintain my identity confidential and that any information I supply to the researcher(s) will be used only for the purposes of the research.
9. I agree to participate in this investigation and understand that I may withdraw at any time without any effect, and if I so wish, may request that any data I have supplied to date be withdrawn from the research.

Name of Participant:

Signature: Date:

Statement by Investigator

☐ I have explained the project & the implications of participation in it to this volunteer and I believe that the consent is informed and that he/she understands the implications of participation

If the Investigator has not had an opportunity to talk to participants prior to them participating, the following must be ticked.

☐ The participant has received the Information Sheet where my details have been provided so participants have the opportunity to contact me prior to consenting to participate in this project.

Name of Investigator

Signature of Investigator

Appendix C

Experimental Session Questionnaire

Note to interviewer: When booking, ask participant not to consume caffeine (2 hrs), tobacco (2hrs), alcohol (24 hours) and illicit drugs (none) prior to session, and let them know that they may have some residual electrode gel in their hair when they leave the session

Experimental session questions

(To be completed on the day of the experimental session)

Date ____/____/____ Participant

ID _____

1. **Check that participant has abstained from alcohol for 24 hours and illicit drug use since completing the screening questionnaire**

3. **How many cups of coffee (or any other caffeinated drinks/products) have you consumed today? _____**

   If > 0. How many hours since your last caffeinated drink _____ hours

4. **Have you had any tobacco or nicotine products today? Yes / No**

   If yes, how many cigarettes (or nicotine products) have you had today? ____

   If yes, How many hours since your last cigarette (nicotine product) _____ hours

5. **Have you consumed any medications in the past week (or any prescribed medications since completing the screening questionnaire)?**

   If yes, please detail:

Medication	Number of occasions	Time since last used	Estimated dose

6. Approximately how many hours sleep did you have last night? ____

Karolinska sleepiness scale (participant can self-complete)

Please circle on the following scale of 1 to 9 how you feel **AT THE PRESENT MOMENT**:

1	2	3	4	5	6	7	8	9

Very alert		Alert – normal level		Neither alert nor sleepy		Sleepy – but no effort to stay awake		Very sleepy, great effort to stay awake, fighting

Appendix D

Computer Game Usage

Date: _____ Participant: _____

Video Gaming Experience Questionnaire

We are interested in how often you play video games, and may use this information to examine the effects of video game playing on visual attention and motor skills.

How often would you normally play video games? Please choose one response.

- ☐ Never play video games
- ☐ Rarely play video games (less than 2 hours a month)
- ☐ Occasionally play video games (between 30 minutes and 2 hours a week)
- ☐ Regularly play video games (between 2 hours and 5 hours a week)
- ☐ Often play video games (more than 5 hours a week)

Appendix E

Menstrual Cycle

Date: Participant:

What was the date of the first day of your last period? If you don't remember the exact date you can give an approximate range (e.g. 5-8 May):

April 2015

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

May 2015

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

June 2015

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

July 2015

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
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26	27	28	29	30	31	